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TRANSPLANTATION OF THE URETERS INTO THE LARGE INTESTINE

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FUNDAMENTAL PRINCIPLE

IT would seem that the valve is the only mechanism by which fluids and gases, at a given temperature, may be transmitted from a chamber of low pressure to one of higher pressure. Without the controlling influence of the valve, the tremendous energy of expanding steam and gasoline would be futile and powerless. Therefore, it may be truthfully said that without the valve principle, our present civilization could not possibly exist.

A valve is a non-motile, movable gate or obstruction which is located at the threshold or in the course of a cavity or canal, and which automatically closes and prevents reflux during the intervals between intermittent applications of the necessary force used in the transmission of fluid matter from an area of lesser pressure into one of greater pressure. In the higher animal mechanism, there are various conditions under which it is necessary to transmit vital fluids forcibly. Under all of these conditions and in all of these locations, non-motile membraneous valves are found. The most important of these valves are those connected with the heart and blood vessels, and those at the entrance of the ureters into the bladder and of the bile duct into the duodenum. Without these valves, human life, and indeed all higher animal life, would be impossible. Therefore, it may be said that the valve is the most fundamental principle or mechanism connected with the activities of our world.

CHRONOLOGICAL STEPS IN THE DEVELOPMENT OF THE OPERATION

Since the dawn of modern medicine, doctors, realizing the successful arrangement of the cloaca in fowls for the common reception of the urine and fæces, have hoped that under certain circumstances a similar arrangement might be surgically produced in the human being. A review of approximately 250 articles dealing with experimental attempts to produce this condition has shown that not one author had up to 1909 constructed a true non-motile valve such as exists in ordinary mechanics or in the cardiovascular system, at the mouth of the ureters, or at the mouth of the bile duct. The presence of muscle fibers near the outlet of these channels seems to have misled the investigators. All reports of experimental attempts to transplant the ureters into the large intestine of dogs prior to 1909 failed to reveal a single instance in which a series of live dogs with undamaged kidneys could be exhibited. There were three notable instances, however, in which a degree of success had been attained by a near approach to the desired solution. Since these three operations have caused a certain amount of confusion, I shall, therefore, in the interest of clarity and

of fairness, quote from the reports published by the three authors.

Fowler operation. George R. Fowler in his *Treatise on Surgery* (1906, ii, 313), described his operation as follows:

> Ureteral and rectal anastomosis offers an ideal method of dealing with the inconveniences and discomforts of exstrophy of the bladder, were it not for the danger of infection of the kidney.
>
> In the case in which I implanted the ureters into the rectum, protecting the opening of the former by means of a flap of mucous membrane and further providing against infection by placing the ureters in the grasp of the circular fiber of the bowel wall, the patient escaped infection as far as any symptoms could determine that fact. Over 9 years have elapsed since the operation and the patient, now grown to be a young man, has apparently suffered no inconvenience from the presence of the opening of the ureters into the rectum.

The four steps of the technique are shown in Figure 1.

It will be observed that Fowler attributes the success of his operation to two features: the mucous membrane flap within the bowel and the muscular action of the intestinal wall around the ureter.

It is at once apparent that this little tongue of mucous membrane, after the catgut attaching the ureters to it has absorbed, would hang as a loose tag in the intestine and would gradually atrophy. Also the muscular action around the ureter would be no greater than any other direct implantation. And yet Fowler's operation succeeded in this case. Why did it succeed? In Figures 1 A and B, showing the outline of the tongue of mucous membrane in the diamond-shaped space, it will be observed that above the cut flap is a small triangular area of mucous membrane (indicated by an asterisk), which has been loosened from the muscular coat for the short space intervening between the point of entrance of the ureters at the upper angle of the wound and the turning in of the mucous flap. For this distance, the ureters actually ran between the mucous coat and the muscle as indicated in F and G (identified by arrows). Figure 1, E shows a sectional view of the mechanics of the operation as described in the text by Fowler. F and G show what really happened as a result of the Fowler operation as shown by his pictures. Arrows point to the submucous space traversed by the ureter. This space corresponds to the space in A and B indicated by the asterisk. G indicates the probable result in Fowler's successful case. The mucous flap hangs as a useless tag. Arrows point to the short submucous space traversed by the ureter which constitutes a short valve. This feature of the result was apparently overlooked by Fowler. Our present day success with implantation of the ureter shows that without doubt this factor accounted for Fowler's success. He had inadvertently applied the principle of submucous implantation and had not recognized it as an essential part of his success.

Martin operation. As early as 1898, Franklin H. Martin was absorbed in a dream of the radical removal of the uterus and bladder for cancer which involved both of these organs, and fully recognized that the chief desideratum in this connection was a practical disposition of the ureters. The following paragraph gives his view on this phase of the question at that time:

> *Transplantation of the ureters into the rectum or sigmoid flexure* is the method which literature indicates has been accepted as the inevitable one by the majority of experimenters, in spite of the objections which may be urged against it. In my experiments in this line I have accepted the lower bowel as the best substitute for the bladder; first, because it possesses reservoir room; second, because it has emptying power under the control of the individual, and finally and principally, because it has a perfect sphincter outlet, also completely under the control of the individual.

No more earnest, industrious, and intelligent experimental surgery has ever been done in connection with this subject than that of Martin. For several years, he worked on animals attempting to solve the problem of transplantation of the ureters. During this time he had at least one dog that survived the operation for 3 months and at postmortem examination showed a fairly good kidney. Nevertheless, Martin gave up in despair as to the value of experimental work and expressed himself in the following words:

> I am convinced that work on animals will never solve the problem of ureterorectal anastomosis. The care of an animal cannot be such that one can minimize, as in the human, several sources of danger of infection. For example: Gravity, as it is

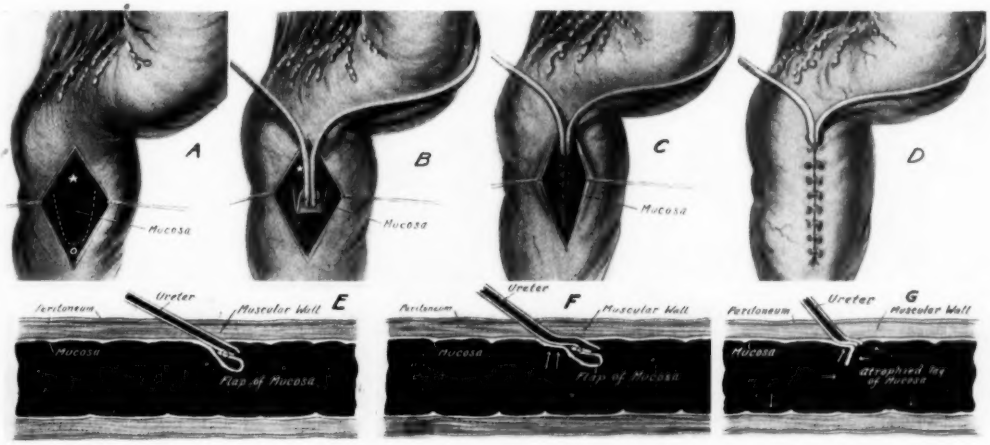

Fig. 1. Fowler operation. *A*, Incision in the rectal wall, including the serous and muscular coats. Mucous membrane exposed in a diamond-shaped area, and the edges of the incision retracted by thread retractors. The dotted line shows the line of section of the mucous membrane to form the tongue-shaped flap. *B*, Tongue-shaped flaps cut and turned back. The ureters are placed with their obliquely cut ends lying on the surface of the flap and secured in place by chromicized catgut sutures. *C*, Flap-valve and ends of ureters placed in the rectum, and a row of chromicized catgut sutures closing the gap in the mucous membrane. *D*, Showing the longitudinal incision in the bowel-wall closed by a row of silk sutures. The ureters are shown passing into the upper angle of the closed incision. *E*, *F*, and *G*, author's interpretation of Fowler technique. *A*, *B*, *C*, and *D*, redrawn from Fowler, *A Treatise on Surgery*.

exerted on the urine of the ureters in the upright human, is lacking in the horizontal animal. The rectum of the human patient can be rendered and maintained relatively clean. The usual location of the implantation in the animal (anterior or lateral wall of the rectum) makes the mouths of the ureters at the most dependent portion of the bowel when the animal is lying, standing, and walking, much more subject to infection. The opposite is the case with the human, and too, the patient can be so controlled that ureteral catheters can drain the ureters for several days after the operation, and the mouths of the ureters protected entirely from infected material, thus giving a start and an immunity when the resistance of the tissues are at their lowest tide.

As far as the printed record shows, Martin was never able to realize his dream of transplanting the ureters coupled with removal of the uterus and bladder for carcinoma. He reported on one dog which lived 3 months and at the postmortem examination was found to have a fairly good kidney as shown by the following pathological report by Professor Zeit, of the Klebs Pathological Laboratory:

The absence of pyelitis in this case contrasts markedly with the findings of former postmortems before this Society, and speaks, in this case, against an ascending infection, from the rectum up. If the left kidney can be taken as a criterion of what is to be expected after such operations, the results might be considered in a more favorable light. It is possible that this left kidney shows what would have become of the right kidney if the dog had been allowed to live. (The left kidney showed in the middle of the convex border a nodular appearance similar to that of the granular kidney of chronic interstitial nephritis).

This was a better result than had been accomplished by previous attempts at direct transplantation of the ureter into a dog's bowel by other investigators.

The following is Martin's description of his operation:

1. Place the patient in a Trendelenburg position; make the abdominal incision so as to expose the rectum; pack back the omentum and intestines; make a longitudinal incision of the peritoneum over the ureters down to their insertion into the bladder and dissect them out with the finger to a height of about 3 inches. Tie each ureter near the bladder with strong silk and sever it above that point.

2. Bring both ureters forward and approximate them in front of the rectum by including the wall of each in one fine silk suture, tied in a hard knot, and armed at each end with long cambric needles. Approximate the ureters further by 2 fine catgut sutures, passed through the outer walls of the ureters only, securing the 2 tubes parallel for a distance of 2 to 3 centimeters. Place the severed ends

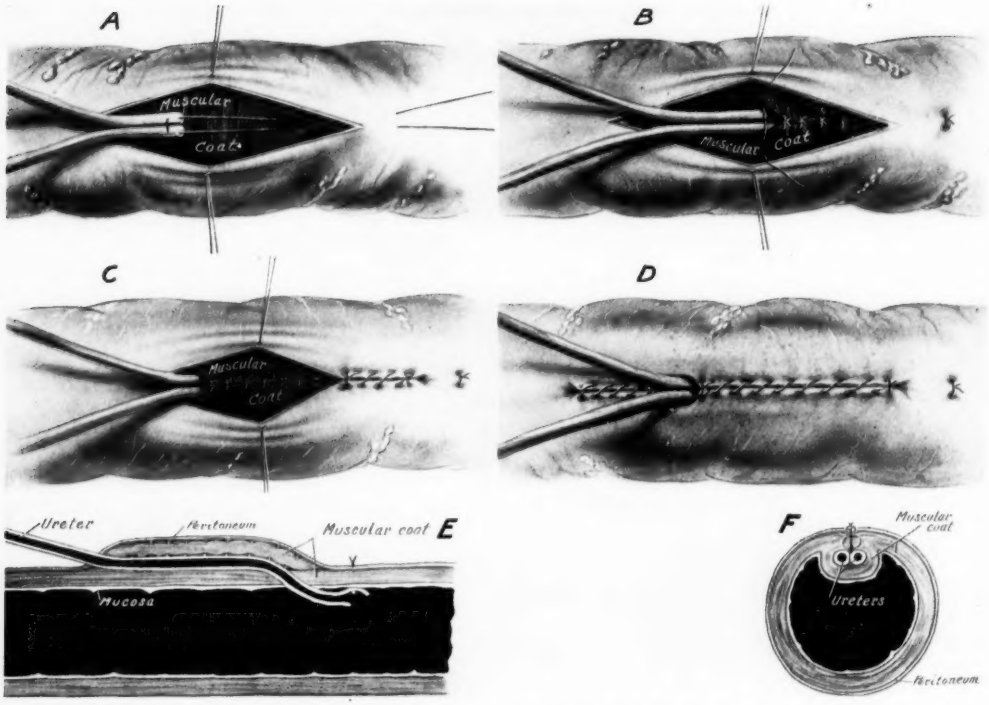

Fig. 2. Martin operation. *A*, Intestine has been split down to the muscular coat; a stab wound made through the muscular coat and mucosa near the lower angle, the two ureters being drawn into the lumen of the intestine. *B*, Ureters have been anchored to the inside of the intestine by the anchor suture; muscle wall being enfolded around the ureter. *C*, Muscular wall has been made to envelop ureters most of length of the wound, peritoneum being closed over other sutures. *D*, The completed operation. *E* and *F*, Shows sectional views of completed Martin operation made to harmonize with his description in the text. The ureters are surrounded by muscle wall. *A*, *B*, *C*, and *D*, redrawn from Martin *American Journal of Obstetrics*, ix, 636.

of the ureters on a gauze sponge while executing the next step.

3. Make a longitudinal incision 2 inches long through the peritoneal and subperitoneal tissue of the upper wall of the bowel and dissect back this tissue so that the oval surface of the muscular coat of the intestine is exposed the length of the primary incision in the bowel and 1 inch wide at its center. The flaps are held apart by silk stays or tenacula.

4. After making sure that the bowel is free of fæcal matter, and having secured it above by a clamp or rubber tubing, make a small incision through the remaining coats of the bowel, large enough to admit the two ureters without pressure, and about 1 centimeter from the lower end of the oval denudation. Pass through this opening into the interior of the bowel downward the double-threaded suture previously placed in the ends of the two ureters, and bring one needle out immediately below the denudation and the other one 2 centimeters below the first one, or about 3 centimeters from the opening made for the ureters, and draw the ureters through the opening to the point at which the upper stay silk found its exit.

5. Elevating the two ureters at right angles to the bowel, while steadying them by the upper stay silk, secure them to the fibrous and mucous coat of the bowel by a number of closely applied sutures of fine catgut or silk, using great care not to penetrate to the mucous coat of the ureters. The ureters are then laid parallel with the bowel on the denuded portion, the lower handling silk is made taut, thus causing an inversion of the denuded surface into the bowel for a distance of 2 centimeters, and additional sutures passed, securing the ureters to the muscular coat of the intestine as it is rolled in by the tension.

6. The ureters are now buried in the muscular coats of the bowel by overfolding those coats for a further distance of 2 to 3 centimeters, the inversion being facilitated by making tension on the lower silk handling string and securing them to the ureters by fine catgut sutures.

7. The peritoneal coat of the bowel is now closed over the ureters to the point where they separate and then below them above that point. This is accomplished by a running inversion stitch of silk. A few additional interrupted sutures of silk or catgut attach the peritoneal coat to the outer coat of the ureters.

8. The ureters should be left protruding into the bowel, when practicable, at the end of the operation, so that the urine after the catheter has been removed will be carried off and discharged at a distance of 1 to 2 centimeters from the point of their entrance into the bowel, in order to protect the wound in the mucous membrane from contact with the urine.

While this reference to the catheters had not been mentioned in the description of the operation and the catheters have not been shown in any of Martin's pictures, in another place in the paper describing the operation for removal of the bladder, the following statement occurs:

At the stage of the operation when I am ready to draw the two ureters into the bowel, I would advise placing a rubber ureteral catheter, with an end opening, into each ureter for a distance of 3 inches, the two free ends being temporarily plugged. The two catheters are thrust through the opening in the bowel and as the ureters are guided into the opening by means of the fixation and handling silks, the free ends of the catheter should be drawn out through the anus and the plugs removed and their free ends placed in separate receptacles. After the ureters are secured the catheter should be fixed to the edge of the anus by two silkworm gut sutures.

He states the principles and purposes of his specific technique as follows:

a. The ureters should empty into the bowel in the direction of its long diameter from above downward, so that the urine shall be discharged in the direction of the fæcal current.

b. The ureters are buried in the walls of the rectum for a distance of an inch or more, longitudinally, so that in the act of defæcation, the fæcal mass will close the caliber of the ureters by its pressure on the mucous membrane, and that pressure is exerted from above downward in the direction of the onward flow of urine, thereby emptying the ureter by a milking process.

c. The ureters are further protected by the muscular coat of the intestine. This is accomplished by surrounding them in their longitudinal course through the intestine to the extent of 2 centimeters by the muscular coat of the bowel. This muscular coat of the bowel in acting from above downward milks the urine downward and holds the ureter closed when the rectum is aiding in defæcation. When the contraction and closure due to defæcation is over, the urine will spurt forth with considerable force, acting as a cleanser to the ureters.

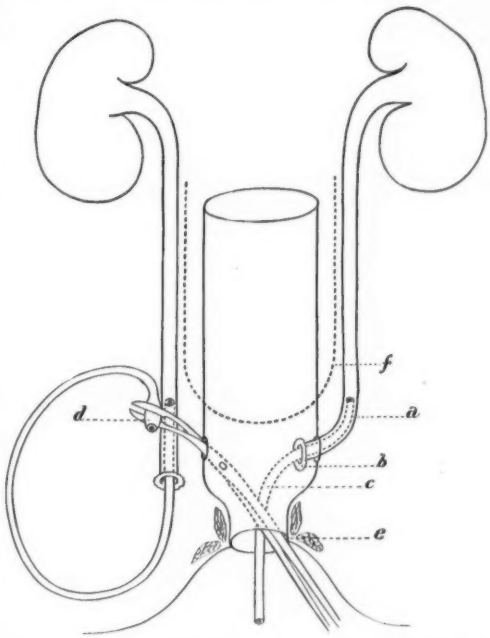

Fig. 3. Peter's operation. Scheme of transplantation of ureters into rectum by extraperitoneal method. *A*, Ureter in transplanted position with, *B*, rosette of bladder mucous membrane and muscle; *C*, catheter stitches into ureter by suture at *B*, and protruding through *E*, the anus; *D*, forceps passed by the anus through the opening in the bowel and grasping the catheter; *F*, reflection of peritoneum.

While it was Martin's announced intention to produce a valve, he in reality produced a sphincter. There is the following difference between a sphincter and a valve:

A valve is a non-motile, movable gate or obstruction which is located at the threshold or in the course of a vessel or tube and which automatically acts to prevent a reflux of matter from an area of greater into one of lesser pressure.

A sphincter is a motile, innervated gate or obstruction which is located at the threshold or in the course of a cavity or canal, for the purpose of retarding the onward or outward flow for the convenience of the biological or animal mechanism.

A valve is equally active in an animate and an inanimate mechanism. A sphincter is effective only when animated or innervated.

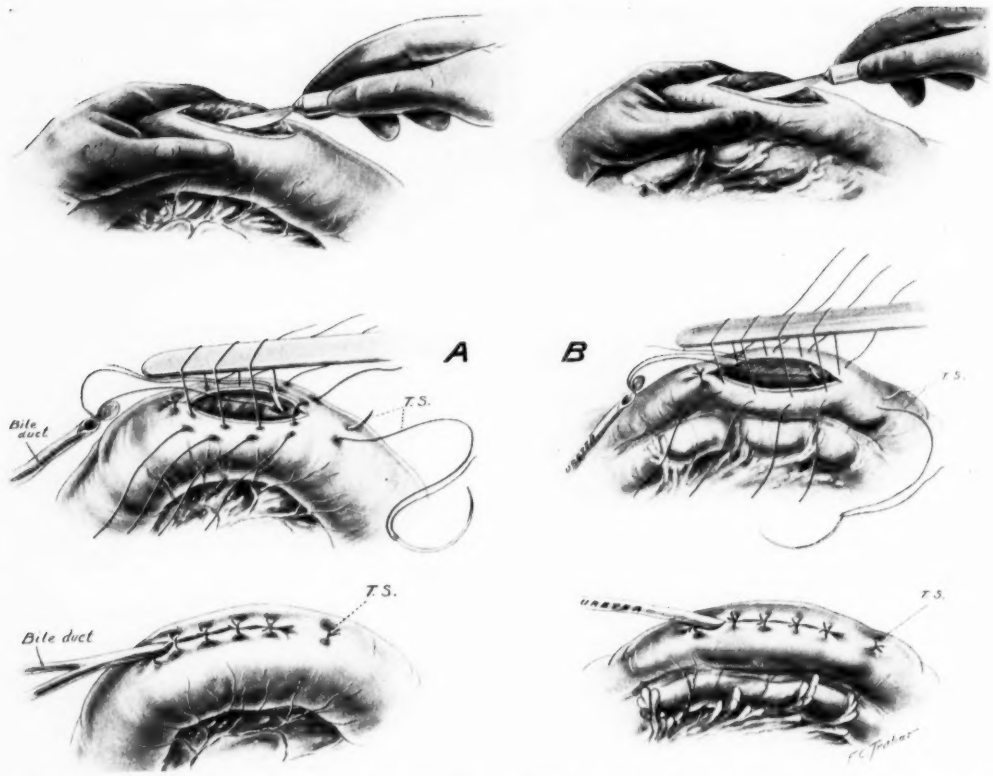

Fig. 4. Original operations for submucous implantation of the bile duct and ureter into the small and large intestine respectively. Drawings of bile duct operation have been redrawn from *Annals of Surgery*, December, 1909; of ureter, from *Journal of American Medical Association*, January 11, 1911.

In the animal mechanism, a valve is found where the activities of vital organs are to be certainly protected. A sphincter is found where function is to be improved. The true valves of the body, such as those which protect the outlet of the ureter into the bladder, of the bile duct into the duodenum, of the heart into the aorta, function just as well after the patient is dead as during life. A sphincter ceases to function during paralysis or at death. A sphincter is a ring of involuntary muscle fiber under the control of the nervous system and therefore subject to remote reflex or psychological influences as exemplified by such pathological states as cardiospasm, pylorospasm, vaginismus, bladder strangury, and spastic sphincter ani. The true valves of the body contain no muscle fibers and respond to no influence save that of the force they are intended to control. Martin's technique was not successful because he did not cut the muscular coat and thus eliminate it from the structure of the valve.

The presence of the sphincter of Oddi near the outlet of the bile duct and the extra-accumulation of circular muscle fibers near the outlet of the ureter have apparently misled investigators into the belief that these muscles are sphincters for the purpose of preventing reflux while as a matter of fact, sphincters are never used for this purpose. It is possible that these circular fibers in both of these instances act like the accelerator urinæ muscle in the urethra and serve as an accessory force by injecting the bile or urine through the space beneath the valve into

the cavity of the intestine or bladder, after which the inanimate flap of mucous membrane, acting as a separate structure, automatically closes to prevent reflux.

Peters' operation. Practically coincidental with the publication of Fowler's statement in his book and of Martin's work, came the publication of a paper by George A. Peters, of Toronto, under the heading of "Transplantation of the Ureters into the Rectum by an Extraperitoneal Method for Exstrophy of the Bladder," which was published in the *British Medical Journal*, June 22, 1901. Peters' operation was a modification and an improvement of the Maydl operation which in reality is not simply a transplantation of the ureter but includes the ureter-bearing segment of the bladder into the rectum. Peters' description follows:

On July 15, 1899, the patient was anæsthetized and the parts were disinfected as thoroughly as possible. The sphincter was well stretched and the rectum, having been previously cleared by a purge and enema, was washed out with an antiseptic solution of non-poisonous strength. A fair sized sponge to which a tape was attached was then passed into the rectum as high up as possible. This not only prevented any passage of fæcal matter, but assisted materially in raising the anterior wall of the rectum toward the bladder. Turning now to the bladder, a Jacques soft rubber catheter (Fig. 3 c, d), about No. 5 (English), was passed for about 2 inches into each ureter. The part containing the eye was cut off so that the urine entered the opening upon the end of the catheter freely. A silk suture was then "caught" through the extreme end of the ureteral papilla (Fig. 3 b) once or twice, and was also passed by a needle through the substance of the catheter so as to effectually prevent its slipping out, as it was the intention to retain these catheters in position at least 48 hours. Care was observed not to obstruct the lumen by passing the thread across it or by tying too tightly. The distal end of the ureter with a goodly rosette (Fig. 3 b) of bladder muscle and mucous membrane was then dissected free, the catheter affording an excellent guide to its position. The idea was that whatever virtue there might be in the peculiar termination of the ureter upon the inner surface of the bladder should be retained when the transplantation was completed. As soon as the entire thickness of the bladder wall (which is here uncovered by peritoneum) has been snipped through with scissors or scalpel, blunt dissection may be employed, and it will be found not to be difficult to free the lower end of the ureter along the wall of the pelvis without injury to the peritoneum.

Both ureters having been isolated, the whole of the bladder tissue was remorselessly ablated, from the perimeter, where it merged into the skin, to the prostate where the vesiculæ seminales debouched. (During this dissection great care must be taken not to expose or injure the peritoneum; and if its hazardous proximity be suspected, a portion of the bladder muscle may be left, though every vestige of its mucous membrane must be removed. In my case the peritoneum gave no trouble whatever and was never in the least jeopardized.)

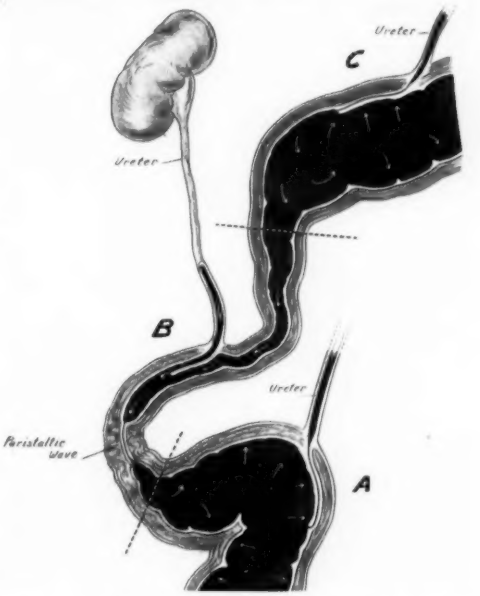

Fig. 5. The modus operandi in the delivery of urine into the intestine. *A*, Segment of intestine in state of rest. Arrows indicate static intra-intestinal pressure holding the valve closed. *B*, Collapsed intestine in which pressure has been reduced by passage downward of a peristaltic wave. Arrows indicate fluid following in the wake of the peristaltic wave. Valve has been opened by the relatively greater pressure in the ureter and the urine is being delivered into the intestine. *C*, After passage of the peristaltic wave, the intestine again assumes a state of rest and the valve is again closed by static intra-intestinal pressure indicated by the arrows.

The next step was to expose the lateral aspects of the rectum at a point below the reflection of the peritoneum (Fig. 3 f). The deep dissection was found to be surprisingly easy, and by pressing back the retrovesical cellular tissue I was able to expose the anterior and lateral walls of the rectum with readiness. This part of the operation was greatly facilitated by an assistant, who inserted his finger into the rectum and lifted it into the wound.

The final step of the operation was the implantation of the ureters into the lateral walls of the rectum, and this was accomplished as follows:

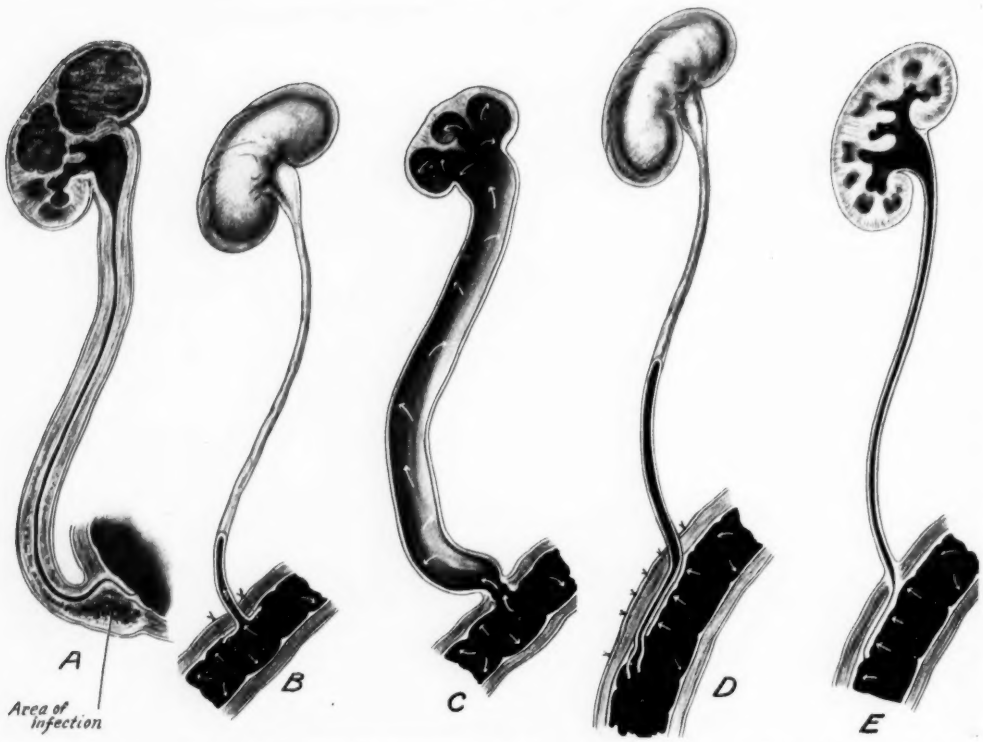

Fig. 6. *A*, True ascending infection emanating from wound in intestinal wall. *B*, Direct implantation of ureter into the bowel. *C*, Dead kidney and dilated ureter which always follows direct implantation. *D*, Ideal submucous implantation. *E*, Undamaged kidney and valve action which follows submucous implantation.

With his finger in the rectum the operator carefully determines the exact point at which the implantation is to be made. The requisite qualifications are: (1) It must be above the internal sphincter (Fig. 3 e). (2) It must be in the lateral and not in the anterior wall, so as to avoid kinking. (This actually occurred in the first instance in the author's case, necessitating a subsequent adjustment of the implantation). (3) It must be high enough up to permit the ureter to project slightly (say ¼ to ½ inch into the lumen of the bowel without stretching (Fig. 3 b). If the ureter thus projects, it forms a papilla, which when pressed upon from within the bowel becomes converted into a valve, similar to that at the entrance of the bile duct and the salivary ducts. This point having been decided upon, the operator or his assistant passes a slender forceps through the anus, presses them against it from the rectal aspect, and lifts it carefully into the anterior wound. The wall of the bowel is now incised upon the projecting forceps, which is then forced gently through. By stretching and cutting, we enlarge the wound with great exactness, so that the ureter with its contained catheter will accurately fill it and yet not be injuriously pressed upon. The forceps are now opened, made to grasp the distal end of the catheter (Fig. 3 d), and withdrawn into the bowel and out of the anus, the operator at the same time carefully directing the ureter through the slit, and satisfying himself that its termination forms a papilla at least ¼ inch long upon the rectal mucous surface. In guiding the mouth of the ureter through the slit in the rectal wall, one may pass the forceps back again beside the catheter, to grasp the edge of the rosette of bladder tissue around the ureteral papilla. This process is repeated upon the other side. The sponge plug is now withdrawn, with care not to disturb the catheters. There seems to be no necessity for stitching the ureters in position, and I did not attempt it. The catheters are left in position at least 2 or 3 days, or until they come away of themselves; in my case in about 60 hours.

The Peters operation is most ingenious and has succeeded in the hands of a number of

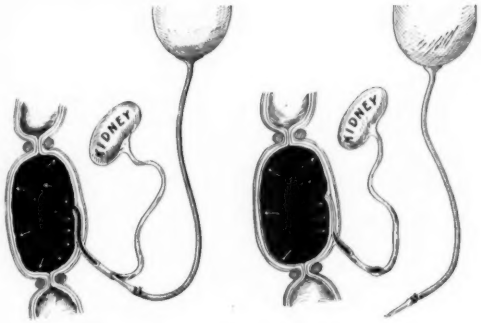

Fig. 7. Segment of intestine into which the ureter was implanted 167 days prior to removal of specimen. The pressure within the intestine closes the valve by pressure on the mucous membrane. Not a drop could be forced back into the duct.

Canadian and English surgeons. By making the operation extraperitoneal, supplemented by drainage, Peters practically eliminates the danger of serious infection. By transplanting the valve mechanism at the end of the ureter from the bladder into the rectum, he has saved the kidney from intra-intestinal pressure, but he in no way utilizes the fundamental principle of surgical valve formation. Therefore, his operation is only applicable to exstrophy of the bladder.

If Fowler had drawn his ureter through a stab wound (indicated by a circle in Figure 1A) in the lower angle of the diamond of mucous membrane instead of in the upper or proximal angle, or if Martin or Peters had cut through the circular muscular layer of the intestinal wall down to the mucosa for as much as one-half to 1 inch, a satisfactory technique would have been evolved by each of these men prior to 1900. They omitted to do this because the problem itself had not yet been isolated and defined.

It would seem that a combination of the Peters, technique with the submucous tube technique described later in this article might be the operation of choice for certain cases of exstrophy of the bladder.

ISOLATION AND DEFINITION OF THE PROBLEM

The problem itself was discovered by accident as an incident in the course of another line of research.

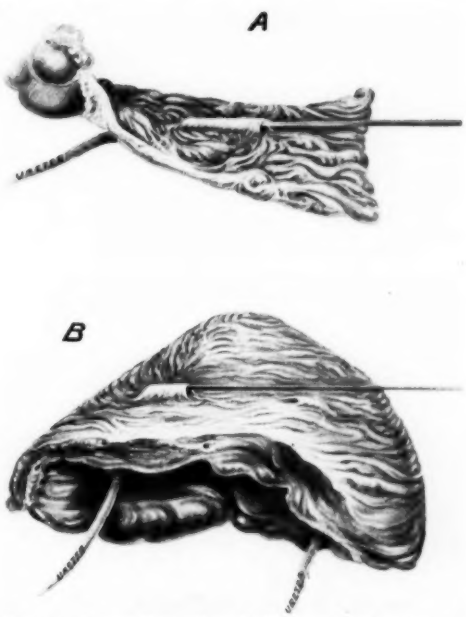

Fig. 8. Comparison of surgically produced valve, *A*, with normal valve in dog's bladder, *B*.

In 1908, at the suggestion of W. J. Mayo, I took up the study of the problems connected with pancreatic surgery. For this purpose, an animal hospital was constructed and specially equipped. In certain experiments on the pancreas, it was found necessary to transfer the delivery end of the common bile duct to a location lower down in the intestine as a preliminary step to surgery of the pancreas. Transplantation was done by the direct method which had been recommended by W. J. Mayo (Fig. 6 B).[1] When the abdomen was opened for work on the pancreas itself, 2 weeks or more after the transplantation, I found that the duct in every instance was enormously dilated. In one instance, it was practically as large as the duodenum itself. The dilation extended all the way into the lumen of the bowel including the opening in the intestinal wall itself. At once the thought occurred that the intra-intestinal pressure must be greater than the intraductal pressure. Hence, the dilatation of the unprotected, thin walled duct. The solution must lie in a study of the mechanism used by nature. Therefore,

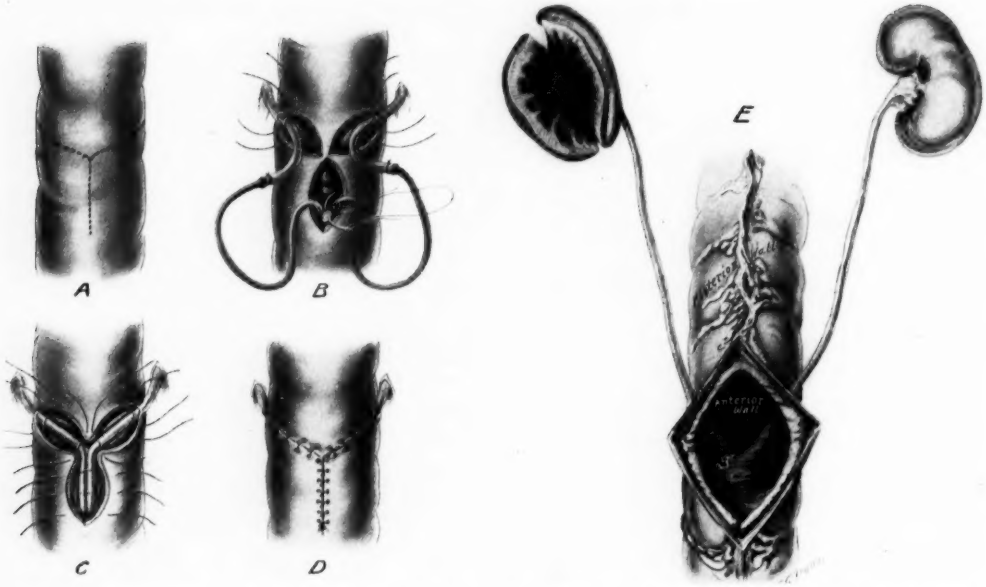

Fig. 9. Bilateral transplantation of ureters at the same intestinal level. *A*, Dotted line shows line of two diagonal incisions emerging into a longitudinal incision. *B*, Three incisions showing both tubes being attached to gauze through a single stab wound. *C*, Technique of placing sutures. *D*, Completed suture line. *E*, Specimen removed from a dog 10 days after operation. (This operation has not been used on a human patient and is not recommended.)

the relationships of the delivery end of the duct were studied in the living dog. It was found that contrary to the mysterious oblique penetration through a complicated muscular wall which had been taught by some authorities, the duct first penetrated the muscle, then ran immediately beneath the loose mucous membrane for a distance before it emerged into the lumen of the bowel. The principles were further studied in dogs' bladders by the construction and application of a similar arrangement to inanimate rubber tubes, rubber bags, and rubber valves. The solution of the technical problem seemed obvious. The duct must lie under the loose mucous membrane for a distance before it enters the lumen of the intestine.

The first method was to make a stab wound through the muscular layer, insinuate the point of a forceps for a distance between the mucosa and muscle; spread the forceps to separate these structures; then with the point of the forceps puncture the mucosa about an inch farther along; insert a grooved director through this canal, pass it for an inch farther on along the inside of the intestine, then pass a threaded needle attached to the end of the split duct along the groove, and bring the needle out through the intestine about 2 inches below the entrance through the peritoneum and muscle wall. In this way, it was hoped to drag the duct through this little canal and anchor it on the inside. This proved to be more difficult than was anticipated and the method was abandoned for a simpler process which consisted of an incision 1 or 1½ inches long through the peritoneal and muscular coats. Through this incision the muscular coat was separated, with the handle of a knife, from the mucosa. A stab wound was made at the lower end of the exposed mucosa and the duct dragged through this opening by a needle and thread which was attached to the split end of the duct as shown in Figure 4 A. The cut edges of the severed structures of the intestinal wall were drawn together across the duct. This left the duct lying under the mucous membrane in

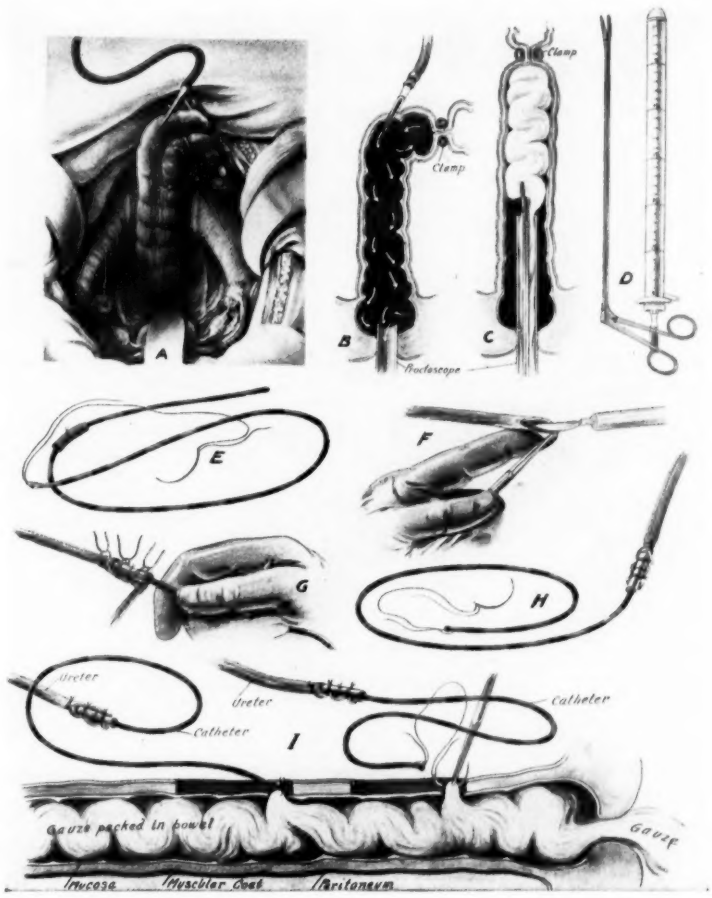

Fig. 10. Preparation of the bowel and ureters. *A*, Bowel clamped, needle for washing inserted. *B*, Cross section showing washing out the bowel. *C*, Packing bowel with gauze. *D*, Sigmoidoscope and laryngeal forceps used in packing the gauze. *E*, No. 12 ureteral catheter, cuff of rubber tubing. *F*, Splitting the ureter. *G*, Catheter inserted into the ureter and tied in place by suture. Note one suture is tied around ureter above the cuff. *H*, Catheter fastened in the ureter. *I*, Showing packed bowel. The function of the gauze in drawing ureters through the wound.

the same relative position to the layers of the intestinal wall as that existing between the delivery end of the duct and intestine in a normal condition.

This operation was performed on 6 dogs under the same circumstances and conditions as were present in the former series of cases of direct implantation. The result was that whereas the ducts were dilated in all cases of direct implantation, no dilatation of the duct was found in any case in which it had traversed the space between the muscular and mucous coats. The problem had been isolated and its solution had been found.

Abstract problem. The delivery of fluid from a viscus of low pressure to one of higher pressure.

Solution. Production of valve action.

Specific problem. The delivery of the fluid of a secreting organ in the ducts of which the

Fig. 11. Ureters mobilized and severed.

pressure must be low and regular into a second hollow viscus in which the pressure is high and irregular.

Specific solution. The production of a valve from the non-motile mucous membrane of the second viscus.

Specific technique. Having the duct of the first viscus run between the mucosa and muscularis of the second viscus for a distance before entering its lumen.

Force making valve effective. The peristaltic wave in the second viscus and in the duct itself (Fig. 5).

The results of these experiments on the pancreas, incidental to which were the discovery and isolation of the problem involved in the transplantation of the duct into the intestine, were presented before the meeting of the Southern Surgical Association in 1909 at Virginia Hot Springs, under the title, "Pancreatoenterostomy and Pancreatectomy," and printed simultaneously in the jubilee number of the *Annals of Surgery*, December, 1909. In closing the discussion on this paper, I made the suggestion that this same principle might solve the problem of ureteral transplantation.

Immediately after this presentation and publication, I began a series of experiments on the ureters, using the same principles. The results were reported and specimens exhibited to the Surgical Section of the American Medical Association at St. Louis in June, 1910, under the title, "Physiological Implantation of the Severed Ureter or Common Bile Duct into the Intestine." Illustrations for the technique adapted to the implantation of the ureters (Fig. 4 B) were submitted and published with the report in the *Journal of the American Medical Association* (1911, lvi, Feb. 11.). The results of these experiments, which were preceded by repetition of bile duct experiments, were summarized in this article as follows:

In 5 dogs with direct implantation of the bile duct, all specimens showed marked dilatation; of the 4 dogs in which the duct was transplanted by the submucous method, none showed dilatation of the duct. Of 6 dogs in which direct implantation of the ureter was performed, 5 died with pyonephrosis as a result of the operation, while the sixth lived and was killed 61 days after operation when it was found that the kidney with the implanted ureter had been totally destroyed, leaving only a shell of fibrous tissue while the ureter was dilated and remained wide open (Fig. 6 c). Thus, every ureter and every bile duct which was transplanted directly into the intestine without valve formation dilated throughout its extent, including its opening into the intestinal lumen. On the other hand, of 9 dogs, in which the ureters had been implanted by the submucous method, 4 had died operative deaths from general complications such as may be encountered in any form of complicated abdominal surgery. The 5 which recovered from the immediate effects of the operation showed undamaged kidneys and undilated ureters when the dogs were killed at periods ranging from 60 to 167 days after operation. Removed specimens when tested showed that the valve action was perfect mechanically in the dead intestine as well as in the living. In Figure 7 is shown a post-mortem experiment which was made in all of these cases. So perfect was this valve in one instance that by using my entire weight and stepping on the obstructed intestine, rupture of the bowel occurred without causing a reflux of the fluid through the ureter which had been transplanted. All the other specimens in this series showed similar valve production. Figure 8 shows the similarity of the valve which has been surgically constructed in the course of the submucous implantation of the ureters to the normal valve in a dog's bladder.

As far as I know, this was the first time that a number of undamaged dog's kidneys

Fig. 12. Traction loops in place for holding bowel while incisions are made. The lower or left incision has been made through the muscularis, the handle of the knife separating the muscle from the mucous membrane.

had been presented before any society following transplantation of the ureters into the bowel. Fortunately, Dr. Charles H. Mayo was chairmen of the Surgical Section of the American Medical Association at the time this work was presented. He saw the kidneys and the valves in the intestine produced by the implantation as well as the technique and recognized the importance of the presentation that had been made.

Dr. Mayo's contribution. Dr. Mayo's relationship to the development of this operation is very direct. Had it not been for his sound clinical judgment, remarkable skill, and his standing in the profession, it is entirely possible that the completed procedure which we are presenting now might have been delayed for many years, for I must admit that there have been many times when I have been discouraged with it myself. Dr. Mayo's results always inspired hope and renewed energy.

After I presented this experimental work and the technique described in Figure 4, it was nearly 2 years before I saw a case in practice to which I could apply it. In the meantime Dr. Mayo had used the operation on 2 or 3 cases for exstrophy of the bladder so that to him belongs the credit of being the first to perform this operation on the human. While Dr. Mayo has never claimed to have added any vital point to the technique of the operation, he added the following personal touches which materially helped to clinicalize the procedure: He used fine catgut instead of linen; he left off the control suture at the upper end of the implantation wound; he used curved rubber-covered clamps for hold-

Fig. 13. Picking up gauze in stab wounds in mucosa.

ing the intestine; he supplemented the interrupted sutures with a continuous catgut; he called attention to the advantages of implanting the right ureter first low down in the rectum and at the same time fastening the parietal peritoneum to the intestine near the anastomosis; 10 days or 2 weeks later he transplanted the left ureter into the sigmoid.

In Osler's memorial volume, Dr. Mayo's article on exstrophy of the bladder sums up his experience at that time:

In our series of 52 patients, 6 were operated on by the plastic method; 1 died 6 months later (traumatic exstrophy at childbirth); 3 patients were operated on by the Maydl-Moynihan method, 2 of whom died of uræmia. Twenty-six were operated on by the transplantation method, 22 successfully; 2 of these patients had but one kidney each. Four died shortly after operation. Seventeen of the 52 patients were not operated on at the time of their examination; some of them were too young and are to be operated on later; others with diseased or dilated ureters were advised against the operation.

In the *Journal of the American Medical Association* (lxxxii, 624), C. H. Mayo and Walters reported 35 cases operated on between 1912 and 1921 in which the ureters had been transplanted for exstrophy of the bladder with remarkable results. (To date Dr. Mayo has done the operation on 93 patients.)

In addition to Dr. Mayo's work, Dr. W. E. Lower, of Cleveland, has performed a number of ureteral transplantations by this first technique. I have transplanted something like 14 ureters by the original technique, while

Fig. 15. Ureters being anchored in place.

Fig. 16. Ureters buried in the intestinal wall by sutures.

a considerable number of individual operators throughout the country have performed this operation successfully by this method. There has always been a considerable element of danger and difficulty in carrying out the proper technique by this original method. It has also been impossible to transplant both ureters at the same time with any degree of safety, probably due to the fact that the œdema following the operation seems sufficient to shut off the flow of urine into the intestine for 2 or 3 days and results in a uræmia in addition to the sepsis.

Because of these difficulties and dangers, few have had the temerity to recommend the operation for anything besides exstrophy of the bladder except in rare instances. This has always been very disappointing and I have always hoped that we would be able to develop a technique which would make the operation safe enough to justify its use in many other conditions which occur much more frequently than exstrophy of the bladder.

DEVELOPMENT OF THE TUBE METHOD

On January 27, 1925, I was holding a clinic for the Northwest Section of the American College of Surgeons. One of my cases was a cancer of the bladder for which we were to do a transplantation of one ureter as the first stage of the operation. On opening the abdomen, to my great dismay, I found the ureter dilated to the size of a man's finger. The wound was closed and no operation done.

About March 30, another patient was referred to me with a hopeless cancer of the uterus, bladder, and the vesicovaginal septum. The patient had had a great deal of distress and presented a picture of despair. The relatives were informed that the only thing that could be done was to transplant the ureters, after which we might use large doses of radium. To this they consented, and on April 4, the abdomen was opened through the right rectus muscle with the view of transplanting the right ureter. It was found dilated to the size of my little finger. The incision was then enlarged and the left ureter inspected. It was dilated also. The operation was being performed in the presence of a class of senior medical students and while discussing it, I evolved the following plan: Mobilize and sever the ureter; insert a small rubber tube well up into the dilated ureter. Place a strong linen thread around ureter and tube in order to anchor the tube; to close ureter against intestinal infection; to stran-

Fig. 17. The ureters being covered by drawing the outer edge of the peritoneum across to the intestine where it is fastened with a suture line. In the lower incision, the ureter has been covered, the space is seen back of the peritoneum which permits of retro-peritoneal drainage. The mesentery of the sigmoid which is here slightly movable is pursed so as to obliterate any space back of the intestine and firmly fasten it to the parietal peritoneum.

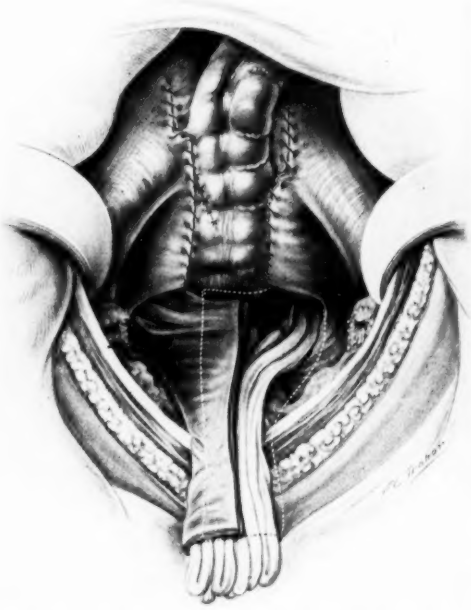

Fig. 18. Two double wicks have been placed in each of the two posterior peritoneal incisions for retro-peritoneal drainage. Two others have been placed in the cul-de-sac intra-peritoneal. A four ply sheet of folded gutta percha tissue is placed above the gauze on the patient's right side. Dotted lines indicate where a similar gutta percha covering is to be placed on the other side.

gulate ureter and permit of automatic removal of tube later. (Tubes and catheters had been used by others before in connection with ureteral transplantation but not in this way and for the same purpose). After the intestinal wound was prepared in the usual way, the small tube, through a stab wound in the intestinal mucosa, could be attached to a rectal tube which had been passed up through the anus. Withdrawal of the rectal tube would draw the ureter into the intestinal wound prepared for it. The ureter could thus be implanted submucously in the wall of the bowel in the same way as if no tube had been used. This was done. The patient was not inconvenienced at all by the operation more than is experienced in any other abdominal operation. The kidney did not cease to function for a moment; in fact it was discharging urine through the tube during the operation and afterward. About 7 days after operation, the tube came away and the ureter discharged urine into the intestine in a normal way.

On April 18, we opened the abdomen on the left side and transplanted the left ureter in the same manner. This kidney also began to act at once and there was not the slightest disturbance from either of these operations. (For convenience of later reference, this case will be designated "Case X".)

By the use of the tube to transmit the urine through the œdematous tissues surrounding the anastomosis, the kidney functions just as if the ureter was brought out through a loin wound or through an abdominal wound. Therefore, it appeared that both ureters might be implanted simultaneously with the same degree of safety that accompanied the implantation of one ureter, and there seemed to be no good reason why, in certain cases at least, the bladder could not be removed and the ureters implanted, making a complete operation at one sitting.

In the meantime, the patient (Case Y) whose abdomen we had explored and abandoned as hopeless as far as transplantation of the dilated ureter was concerned, continued to suffer severely and insisted that something be done regardless of the risk. It finally occurred that possibly the left ureter might not be dilated, so that on February 12, 1925, we opened the abdomen on the left side and found that the left ureter was not dilated. We therefore transplanted the left ureter into the sigmoid by the original submucous implantation technique. In due time the kidney began to deliver its urine into the bowel and worked perfectly. The urine from the right kidney, of course, kept up the continuous distress and strangury in the bladder, but we had in mind ligation of the right ureter for the purpose of killing the right kidney or even doing nephrectomy as soon as it could be established that the left kidney was doing full function. In the meantime, we had transplanted the ureters in Case X by the tube method so that instead of killing the right kidney as planned, we again opened the abdomen on the right side and transplanted the right ureter by the tube method on April 14, 1925 (Case Y). The patient was immediately relieved of his bladder distress. We used some large doses of radium in the open bladder to destroy the local growth if possible. Finally, the patient was discharged. He was secreting urine perfectly and was able to hold it as long as 6 hours. When last heard from, 8 months after operation, he was still quite comfortable although his growth was gradually depleting him. From this time on we were unable to trace him as he had moved to eastern Canada.

After the transplantation of the second ureter in Case X in which the tubes were used, a large dose of radium was used in the vagina for the purpose of destroying the foul odor. About 2 weeks after the last transplantation, an abscess developed in the abdominal incision through which the left, or second, ureter had been transplanted. The abscess was large and sepsis was considerable. The patient died of exhaustion about 6 weeks after the second transplantation. Clear urine was discharged through the rectum up to the time of the death of the patient. A postmortem

Fig. 19. Completed operation without drainage.

examination showed the right kidney to be in splendid condition; the left kidney was filled with multiple abscesses which seemed to have extended up the ureter from the abscess which evidently emanated from the site of transplantation.

EXPERIMENTAL SURGERY

The result of this postmortem examination sharply brought out the fact that there were other problems yet to be solved, not the least of which was local sepsis emanating from the site of implantation. Plans were therefore carried out for doing experimental surgery on a larger scale than we had hitherto done. Space was procured in connection with the University of Oregon Medical School. In order to guard against every fault in technique, my full surgical operating team was brought into the work. The most pressing problem to be solved was that of cleansing the lower bowel in order to free the field from sepsis as far as possible. A plan was decided upon. The lower bowel must be isolated. Accordingly, rubber covered stomach clamps were placed across the sigmoid above the field of operation. A large needle (No. 13 Lewishon

Fig. 20. Implanting one ureter without tubes by the original technique. The sigmoid is still stuffed with gauze. Grooved director passed through the stab wound at lower end, lifts up the bowel to prevent catching the gauze with the needle. Needle being passed along the grooved director penetrating the bowel for the purpose of anchoring the end of the intestine inside. Ureter is then buried as shown in the preceding pictures.

transfusion needle) was procured and attached to the tube of an irrigator. A sigmoidoscope was inserted into the rectum, the water turned on in a large stream, and allowed to run until the water came clear through the sigmoidoscope. All the water was then drained out through the sigmoidoscope and the obturator was re-inserted and the instrument passed up to a point near the clamp obstruction. With long laryngeal forceps, gauze strips were packed into the gut through the sigmoidoscope until the rectum appeared stuffed. This was a great improvement as the gauze not only made the intestine easy to handle but absorbed all the moisture inside the intestine. Furthermore, the ureteral tubes could be attached to the gauze instead of the rectal tube.

The next obstacle that was encountered was spasm of the dog's ureter which made it very difficult to introduce a soft tube of sufficient size to carry the urine for more than a day or two. Every type and variety of tubing was tried. Finally, silver tubes and gold tubes were constructed to which the rubber tube might be coupled. A certain

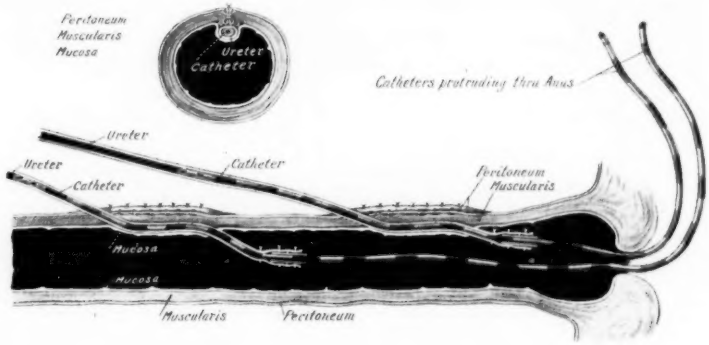

Fig. 21. Scheme of bilateral transplantation of ureters, tube technique. Sectional views.

amount of success followed their use but they were never a complete success. The ordinary ureteral catheter was difficult to hold in place and its caliber became obstructed very frequently by incrustation within the lumen. Therefore, a search for larger sized ureteral catheters was made. Finally it was found that C. L. Bard and Company, of New York, made ureteral catheters of sizes as large as No. 12 but owing to the smooth surface of such a catheter, there was no way to anchor the ureter to the catheter. Therefore, a small cuff of soft rubber tubing was slipped over the catheter and fastened by a ligature or two, making a perfect anchor. After we had solved all these problems, the results upon dogs were much better than we had had before.

One very interesting experiment was made in the way of bringing the ureter diagonally forward on each side of the rectum in a diagonal slit. The two slits came together at a point on the front of the rectum. From this point of convergence, a single slit was made an inch or more down the front surface of the rectum. Finally a stab wound was made at the lower end of this anterior incision and the tubes and ureters drawn through a single stab wound (Figs. 9 A, B, C, and D). This was a very convenient operation and the experimental results were very good (Fig. 9 E). It is barely possible that this operation may have merit, but we have not so far done it on the human being.

Many other details were worked out until a very definite and workable technique had been completed. Our experiments showed very clearly that the tube technique not only carries a lower mortality but also gives better functional results afterward than the original transplantation without the tube. However, the principal superiority of the tube method is that both ureters may be transplanted at the same operation. The final results of the operation on dogs were not tested out by me, but an article published in the May, 1928, issue of the *Journal of Urology* by Charles Morgan McKenna of Chicago supplied the missing link. I have his permission to quote from his article:

I thought it would be desirable and valuable to make some experimental investigation with a view of ascertaining what such kidney function, pathology and bacteriology, may be following ureteral transplantation. For this purpose we have operated on 14 dogs and 1 human being, using the Coffey (tube) technique.

The work of ureteral transplantation was started in October, 1925. The first 5 dogs operated on died with one exception. At autopsy the same pathological condition was found in each dog. Death was not due to the Coffey technique, but to our own fault in carrying it out. In these dogs, we failed to draw the ureter far enough into the lumen of the bowel and secondly there was too much tension on the ureter, the result being a suppuration at the site of transplantation into the bowel and hence an ascending infection into the kidney producing an acute pyelitis and general peritonitis. Perfecting the technique by taking away all tension from the ureter after transplantation and introducing the ureter far enough into the bowel produced results and we showed that the urine emptied freely into the lumen of the bowel. The dogs made a good recovery from the operation and were allowed to go

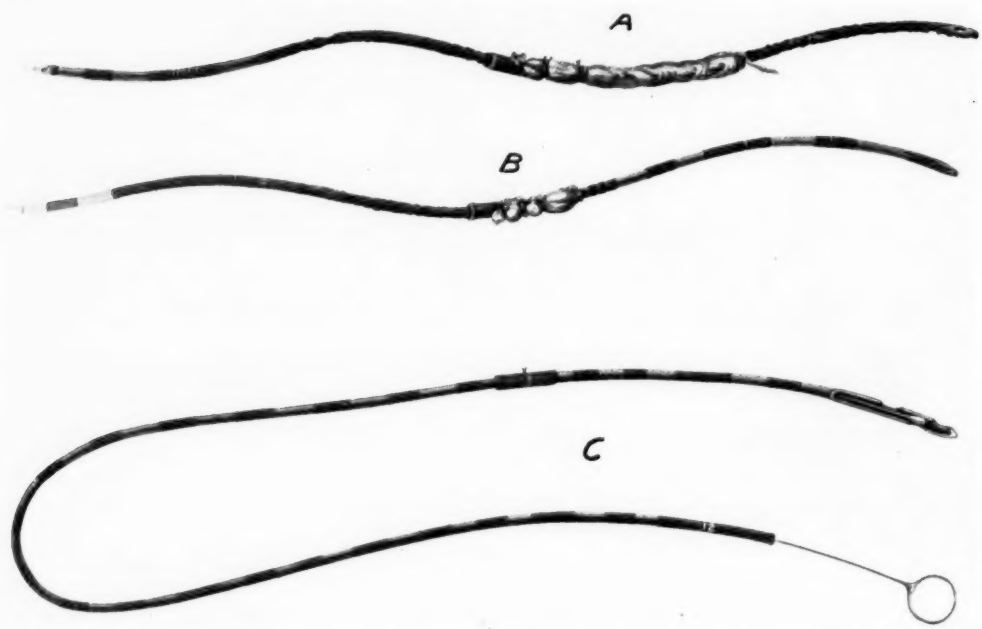

Fig. 22. *A*, The catheter as it came from the left ureter. Note that it sloughed at the point of entrance into the lumen of the bowel. *B*, Catheter from the right ureter which also sloughed at its entrance into the lumen of the bowel. Note that in *B*, the catheter is not eroded, in *A* the catheter end is seriously eroded. This ureter was much dilated and thin while the left ureter containing catheter *A*, was more nearly normal in size. *C*, Spangler's plan for keeping the catheter open. An oblong bulb is braised on the end of a piano wire which is passed up through the catheter but which will not pass out through either of the eyes.

on to complete convalescence and were later studied for function and bacteriology and finally, pathology.

We are reporting the results only of single transplantations for the reason that in these dogs the normal side was used for a control.

Dog 6. A medium-sized white, short haired male was operated upon December 7, 1925. The left ureter was isolated and transplanted into the sigmoid by the same technique as previously described. In this operation the sigmoid was fastened to the lateral pelvic wall by one catgut stitch.

On January 4, 1926, the dog was in good condition and continued to improve throughout the next year. On February 7, 1927, 1 year and 2 months after the first operation, the dog was again anæsthetized and a midline incision made. The left ureter was isolated, then incised, and a ureteral catheter inserted. There were a few adhesions about the site of anastomosis but not marked. The right ureter was also isolated, incised and a catheter inserted. A kidney function test was done, 1 cubic centimeter of phenolsulphonephthalein being used, with the following results: from the right kidney the dye appeared in 3 minutes in good concentration; from the left kidney the dye appeared in 3½ minutes in good concentration. The dye showed 25 per cent on each side in 15 minutes. The dog was killed with ether. Autopsy showed that the right kidney was entirely normal. The left kidney was smaller than the right and was scarred at both poles. The capsule was scarred and thickened at the poles. The pelvis and ureter were of normal size. The anastomosis was well healed but there was some thickening of the left ureteral wall in the distal third. The opening of the distal portion of the left ureter into bladder was not found.

Dog 7. A small, brown male was operated upon December 15, 1925. The operation consisted in anastomosing the left ureter to the sigmoid, the same technique as has been previously described, being used. This dog made a complete recovery and 2 years later (February 1, 1927) was again anæsthetized, the ureters were isolated, incised and catheterized. Urine was collected for culture. The functional test showed the appearance of the dye within 3 minutes from each kidney. The dye was in good concentration. In 15 minutes the dye showed 22 per cent on the left side and 24 per cent on the right side.

The dog was killed with ether. Autopsy revealed the anastomosis well healed and the left kidney of normal size. There was very slight scarring of the

capsule. The right kidney was enlarged, the ureter thickened, and marked hydronephrosis was present. No scars were present. The ureter was patent and a probe could be passed from the ureter into the bladder. There is no explanation for the hydronephrosis on the unanastomosed side unless pelvic infection secondary to operation caused a peritonitis. Dogs 8, 9 and 10, were operated upon December 9, 11 and 13, 1925, respectively, the Coffey technique as previously described, being used.

On February 8, 1927, 1 year and 2 months after operation, these 3 dogs were anæsthetized in the same manner as Dogs 5, 6 and 7. The right ureter which had been transplanted in the previous operation was isolated and a double ureteral catheterization was done by making a small slit in each ureter. A kidney function test was done, 1 cubic centimeter of phenolsulphonephthalein being used, with the following results:

Dog 8. The dye appeared on the good side in 3½ minutes and on the right or transplanted side in 4 minutes. The function on the left side was 22 per cent in 15 minutes, while on the right it was 18 per cent. Bacteriology was negative on both sides.

Dog 9. The dye appeared on the left side in 3½ minutes and on the right or transplanted side in 4½ minutes. Function was equal on both sides: 21 per cent in 15 minutes. The urine was negative on both sides.

Dog 10. The right ureter was found to be slightly larger than the left. The right was the transplanted side. In the dye test the dye appeared on the left side in 3½ minutes and on the right side in 6 minutes. Laboratory analysis showed colon bacillus in the urine from the transplanted side and sterile urine on the left side.

In this case the transplant was made into the bladder instead of into the bowel. Hydro-ureter and hydronephrosis were marked, especially the hydroureter. This was due to a constriction of the ureter at the place where the transplantation into the bladder was made. We tried to use the technique as in the bowel, but apparently the bladder does not work with the same valve-like mechanism. In other cases where we made a transplantation into the bladder, we found we were inclined to get a hydroureter, which proves pretty conclusively that the Coffey technique is the one of choice in the bowel.

Those who have had experience with transplantation of ureters in dogs will appreciate the remarkable success of Dr. McKenna in which he has had 5 consecutive ureteral transplantations in dogs in which the animal lived more than a year and in which practically normal functional results were obtained. Every surgeon who has had both experimental and clinical experience realizes how much more difficult it is to get results in the case of a dog than in the human. The dog seems to have poor resistance to colonic bacteria, and this particular operation is far more fatal in the dog than in the human.

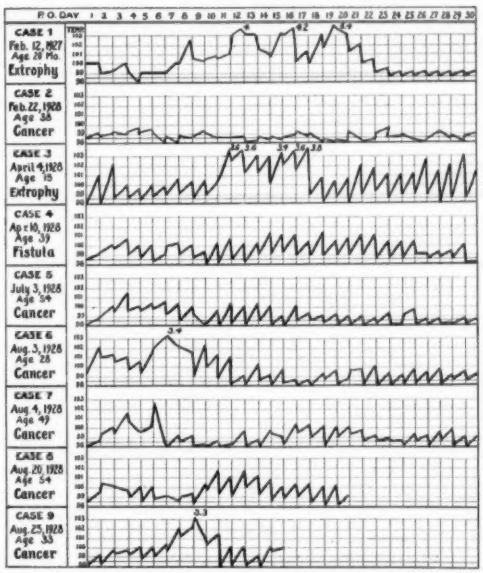

Fig. 23. Comparative temperature chart for all cases.

TECHNIQUE

It goes without saying that the fundamental proposition forming the background of any successful technique for transplantation of the ureters into the bowel is that valve action must be produced. A valve to be always effectual must be unanimated and uninfluenced by muscular structures. The mucous membrane is the only available structure meeting this requirement and is the one which has been universally used by nature for such a purpose. The fundamental point in the technique is that the ureter must be made to run immediately under the mucosa for a distance before it opens into the lumen of the bowel.

The two other important features to remember are:

A. The kidneys are vital organs and life can last only a short time without their function. Therefore, the operation must be so arranged as to interrupt renal function as little as possible. After every wound, an

exudation which produces a certain amount of swelling takes place in the neighborhood of the wound. It seems that when a ureter is transplanted, the swelling in the wall, at least in certain instances, temporarily retards or completely blocks the flow of urine from that kidney. If both ureters have been transplanted without the provision for the free passage of urine, the patient will often die from uræmia. Sometimes this swelling does not obstruct the ureter but it is generally conceded that bilateral transplantation of ureters without this provision is very dangerous. To provide against the serious interruption of renal function during the days immediately after operation, three plans have been used:

1. Transplantation of one ureter at a time through separate incisions, the operations being from 10 days to 2 weeks apart.

2. Unilateral or bilateral transplantation of ureters preceded sometime before by bilateral nephrostomy.

3. The tube or catheter technique in which catheters of sufficient size are used to transfer the fluid through the operative field during convalescence.

By the first plan, two major abdominal operations are necessary. By the second plan, two loin incisions are made at one time, followed later by an abdominal operation. By the third plan, the tube or catheter technique, only one operation is required and only one abdominal incision.

B. The operation must be done in an essentially septic field. Infection emanating from the site of transplantation is often fatal and is always detrimental to the final result. Therefore, every effort to sterilize the field and produce an aseptic operation should be made. The plan for bringing about an aseptic field is equally applicable in each of the three plans.

There will be times when each of these plans will have its advantages. Plan 1, using the type of technique described in St. Louis, 1910 (Fig. 4 B), might be made necessary because of the smallness of the ureter; the inability to secure proper tubes or catheters; or in an emergency in which a ureter has been injured. Plan 2 (Hinman's) will be indicated when the ureters are too much dilated to permit of transplantation into the bowel, in which case a bilateral nephrostomy combined with ureteral catheters in the ureters would permit the ureters to become reduced in size and also permit the infection to be cleared out by irrigation, the transplantation operation to be done later at an opportune time. It might also be indicated in sub-standard patients or in cases in which an obstruction at the neck of the bladder has temporarily damaged the kidneys. Plan 3 should be used as a routine procedure except for the special indications already enumerated.

Assuming that the operation is to be done on Saturday, an ounce of castor oil is given on Thursday and again on Friday morning. On Friday evening and again early Saturday morning, the bowel is flushed with a high enema of clear water. A light diet is given on Friday and the patient is induced to drink all the water possible. At 7:00 a.m. Saturday, ¼ grain of morphine and 1/150 grain of atropine are administered and a rectal tube is placed in the rectum to carry off any fluid which may come down. A general anæsthetic is started at 8:00 a.m. An incision extending from just above the umbilicus to the pubic bone is made just to the left of the middle of the abdomen. All the intestines except the sigmoid are carefully packed back and held above the promontory of the sacrum with a 5 yard pack of gauze. A thin bladed, curved, rubber-covered, stomach clamp is now placed on the sigmoid 12 to 14 inches above the anus, thus isolating this lower segment.

The patient is now drawn down to the end of the table so that the buttocks protrude beyond the table. A skilled assistant inserts a sigmoidoscope, 30 centimeters long, into the rectum and on into the sigmoid, guided by the operator's left hand manipulating within the abdomen. A tube 2 feet long in which has been fastened a beveled edged needle (No. 13 Lewishon transfusion needle) is coupled to the tube of an irrigator which is arranged at considerable height. The needle is thrust through the wall of the sigmoid just below the clamp and the water is turned on. The sigmoidoscope is drawn down so that the end is within an inch or 2 of the anus.

The water, when it begins to flow through the sigmoidoscope, usually contains small particles of fæcal matter and mucous. As soon as this is entirely clear, 500 cubic centimeters of a 1 per cent solution of mercurochrome is put in the irrigator (as suggested by Dr. L. L. McArthur, of Chicago, in a personal communication). After the irrigation is finished and the fluid has entirely drained away through the sigmoidoscope, the obturator is again inserted and the sigmoidoscope under the guidance of the operator's hand within the abdomen is pushed upward to within an inch of the obstructing clamp. Sterilized gauze packing, folded from a strip of gauze 4 inches wide and extending to a length of about 10 feet, is now used to pack the lower bowel. For this purpose, a laryngeal forceps with a straight shaft of somewhat more than 30 centimeters is used. As the assistant from below introduces the gauze with forceps, the placing of the gauze is guided by the operator's left hand within the abdomen. As the bowel is filled with gauze, the sigmoidoscope is gradually withdrawn. The assistant is carefully instructed to include a considerable mass of gauze in his forceps so as to prevent the end of the forceps from injuring or penetrating the intestinal wall (Fig. 10). After the segment of bowel from the clamp downward has been filled with sterile gauze, the patient is drawn back on the table and placed in a moderate Trendelenburg position.

The posterior parietal peritoneum is now incised over the most convenient approach to one ureter. Through this incision, the ureter is located and picked up on a smooth retractor. The incision is extended both ways as much as needed to expose the field. The finger, curved under the ureter, is slipped down like a hook toward the bladder freeing the ureter of its connective tissue and pushing down the structures of the broad ligament in a woman, to a point as near its entrance in the bladder as possible. Under the guidance of the left index finger used as a hook, a small Kocher clamp is placed on the ureter. Another is placed just proximal to it. The ureter is now severed with a knife (Fig. 11). The distal stub of ureter is tied with catgut just below the forceps. If no drainage is to be used, the stump should be cauterized with carbolic acid. The other ureter is lifted in like manner and the two clamped ureters are drawn through the upper end of the wound. If drainage is to be used (and my personal opinion is that it is safer, particularly for one doing his first operation of this kind), gauze is packed into and over these slits in the peritoneum while the further steps of the operation proceed. (In order to keep the steps all clear, the peritoneal slits have been left exposed in the illustrations.)

Two No. 12, whistle tip, ureteral catheters have been sterilized and prepared by fastening a cuff of rubber tubing on the catheter about 6 or 7 inches from its tip. At the other end of the catheter is fastened a double linen thread armed with a round needle to be used in fastening the end of the catheter to the gauze within the rectum. The end of one of the catheters has been sloped for identification. The clamp holding the ureter is taken in the left hand while a knife in the right hand splits the anterior wall of the ureter. A catheter is now inserted into the first ureter down to the rubber cuff. Two strong double linen ligatures are now tied around the slit portion of the ureter and around the anchor cuff. A third strong linen suture is placed around the ureter above the cuff for the double purpose of completely shutting the intestinal contents off from the ureteral canal and of furnishing strangulation of the ureter at this point so as to form a line of separation later (Fig. 10).

Attention is next turned to the intestinal part of the operation. The lowest point in the sigmoid at which the operation can be conveniently done is to be considered the site of election. Using two incisions, I have found it more convenient to transplant the left ureter in the lower incision. The lower end of the upper or right incision, should be at a higher level on the intestine than the upper end of the lower or left incision. The incisions are made diagonally about an inch and a half in length, extending from the mesentery's edge downward and toward the midline of the intestine. While on dogs, I have successfully and easily performed the operation in which the incisions were made on the same level and the

ureters brought out through a single opening (Fig. 9) and while Charles Morgan McKenna, of Chicago, experimentally and Herbert Coe, of Seattle, clinically have transplanted both ureters through a single longitudinal incision with separate stab wounds in the mucosa for each of the two ureters, I think two separate incisions at different levels is possibly the best plan. Using this plan, two traction loops of No. 0 catgut in which both ends are left long are placed at each end of the proposed incision about ½ inch apart and including the muscular coat of the bowel, also including any nearby vessels which cross the incision and which might bleed during the operation.

With traction loops made taut, the surgeon with a fine bladed knife carefully makes each incision through the peritoneal and muscular coats. With the handle of the knife, the muscular coat is pushed off the mucosa (Fig. 12). The ureter is now placed between the two upper traction loops of each excision. With a fine sharp pointed knife, a small stab wound is made through the mucosa at the lower angle of the incision. A very fine Halstead mosquito forceps is thrust through this tiny opening where it seizes a bite of gauze within the intestine (Fig. 13) and pulls a small bit of the gauze through this puncture. To the gauze in these two wounds, the two catheters are sewed (Fig. 14, frontispiece). It is important at this juncture to determine and record which ureter contains the catheter with the sloping edge.

At this point, the nurse begins to withdraw the gauze from the anus. As the gauze begins to tug on the lower catheter, the surgeon carefully guides the end into the bowel. The gauze is pulled down until the end of the lower catheter comes through the anus. Then the pull is made on the catheter. When the end of the ureter around the cuff approaches the wound it is sometimes necessary to dilate the opening in the mucosa slightly so as to permit the ureter to enter the bowel. After it is pulled down comfortably taut, the nurse again pulls on the gauze until the end of the other catheter approaches the opening. This catheter is pulled down in the same way as the first one. At this point it is just as well to remove the remainder of the gauze because it may be inadvertently picked up by a suture and may make trouble in pulling it out later.

With the ureters lying comfortably in their relative incisions, the two traction sutures at the lower angle of the lower incision are made taut. A fine curved needle threaded with No. 000 chromic catgut, double thread, is passed through the peritoneum and musculature of one side of the incision, and picks up a good bite of the ureteral wall, then the other side of the intestinal wall, thus fixing the ureter in the lower end of the wound (Fig. 15). It is probably well to use two sutures which take a bite of the ureter. The sutures are usually tied as they are placed rather than all left loose as shown in the illustrations. The other sutures pick up the intestinal wall just outside of the incision and roll the edges in over the ureter. These may be of No. 0 catgut. The traction loops may now be cut or tied together and another line of sutures, either continuous or interrupted, may be used to cover in the first line (Fig. 16). The ureters, after the operation is complete, should be covered in by peritoneum and not left exposed to the intestines.

If drainage is to be used, a continuous suture begins to bring the edges of the peritoneal incision together just above the ureter. After the second or third stitch, the inner edge of the peritoneum is dropped and the outer edge is drawn over to the side of the intestine where it is sutured and from which point the continuous suture follows the intestine downward, partially covering the line of suture. As it approaches the lower end, it turns outward toward the inner cut edge. This leaves a retroperitoneal space through which any infection that may emanate from the line of sutures, may travel downward to a drain (Fig. 17). The lower part of the incision is left open. The four ends of two double wicks are placed in the lower angle of each peritoneal incision. Two more double wicks are placed in the cul-de-sac. Two folded sheets of gutta percha tissue cover in the gauze so that no intestine can touch it and the wound is closed leaving this quarantine pack coming from the lower end of the incision (Fig. 18). One week after the operation, the gauze wicks

are carefully and separately withdrawn; 4 to 7 days later the gutta percha is removed and the wound is allowed to heal of its own accord.

The method of construction of this quarantine drainage is described in *Annals of Surgery*, June, 1927. Some, of course, may prefer simple rubber tissue drains, some tube drains. Because of the danger of intestinal obstruction around such a drain, however, I think it is better to use no drainage at all than to use anything except the quarantine which I have described. This method of quarantine drainage makes the operation very safe. Undoubtedly many operators will prefer to do the operation without drainage. If the abdomen is to be opened later for such operation as removal of the bladder, it would be more convenient to have no drainage at the transplantation operation.

At the end of the operation, a fold of parietal peritoneum is drawn over the ureter to the intestine (Fig. 19).

There will be times when proper tubes may not be available or when, for other reasons, it will be necessary to transplant the ureter without a tube. In such cases, the same method of cleansing the bowel which has been described for the tube technique will be equally applicable. The dangers and difficulties which were experienced in the past in connection with unilateral transplantation without the tubes will be greatly abated. The same technique as has been described for the transplantation by the tube technique will be applicable except that the end of the ureter must be fixed by a suture to the inner side of the intestine, distal to the wound of entrance. In order to avoid the embarrassment of picking up the gauze within the intestine on the needle carrying the anchor suture, a grooved director is passed through the stab wound and its point made to lift up the wall of the bowel. A curved needle carrying the anchor suture is then passed along the grooved director where its point punctures the intestine. The needle is then drawn through and by pulling on the thread, one can drain the end of the ureter inside the intestine. By picking up a bite of the intestine near the place where the anchor suture has come through, one may tie a knot so as to anchor the split end of the ureter in place (Fig. 20). The sutures are then placed by the same technique that has been described for the tube technique.

POSTOPERATIVE COURSE

During the progress of the operation, subpectoral infusion of normal salt solution is given for the purpose of increasing the flow of urine as well as supporting the patient. Sometimes the urine discharges throughout the course of the operation. On the other hand, it is sometimes 3 or 4 hours or even longer after the operation before the urine discharges in any amount. The ends of the catheters are covered with absorbent cotton which is fastened on them with adhesive plaster. As soon as both catheters begin to discharge freely, the covered ends are kept in a urinal which has been sterilized. While the operation is as a rule, unusually free from shock, it is a fact worthy of note that the pulse in most cases has been fairly rapid for a few days. Subpectoral infusions are used freely for the double purpose of sustaining the patient and increasing the output of urine.

Occasionally a little blood appears in the urine of a kidney and in one instance a little clot formed in the catheter, but was easily sucked out by aspiration. Hinman has suggested washing out the catheter with 2 per cent boric acid solution to keep the opening clear. In one instance, a catheter stopped running because of incrustation of urinary deposits inside the catheter. By cutting off an inch or 2 of the catheter, the urine started again. If the operation has been in a child for exstrophy of the bladder and the tube has been smaller than No. 8, and becomes obstructed, it may be necessary to put in a speculum under anæsthesia and to cut the catheter loose from the ends of the ureters. This was done on the fourth day in Case 1 of this series. This procedure was first carried out on one of my cases by my former associate, Dr. Wayne J. Stater, who later wrote of it in the *Northwest Medicine*.

If the ureters are dilated and œdematous, the catheters sometimes come away as early as

the fifth day. If the ureters are relatively normal in structure, they remain longer and come away between the eighth to sixteenth day.

If urine stops flowing through a No. 12 catheter, it will usually be found that the ureter inside the rectum is beginning to slough and leak. The tube is then ready to come out. An interesting fact has developed in this connection. The part of the ureter which protrudes into the intestinal lumen dies back to the mucosa and when the tubes have remained more than 8 days, all that portion of the ureter within the intestine comes away with the tube. Figure 22 shows the typical appearance of the two tubes and the piece of ureter that they bring with them. The long piece came from the right or upper ureter. In this case the ureters were dilated and very thin at the time of operation. They came away 5 days after the operation, at least one ureter first leaking into the bowel which led to the removal of the tubes at this time. The right ureter pulled out with difficulty; possibly too much traction was made on it. At the upper end will be noticed a small strip of tissue which is probably a piece of ureter which pulled out of the side. Leakage of urine followed at this point. It is probable that this ureter was still intact and that the tube was simply obstructed.

My associate, Dr. Paul E. Spangler, has recently braised a small bulb on the end of a piano wire which he can push down the catheter so as to remove obstruction of any kind. With this wire, the catheter may be kept open. The wire cannot be pushed through the whistle tip opening and yet it completely cleans the lumen (Fig. 22 C).

In only one case was the ureter cut off by the isolation ligature which was put on for that purpose. Almost every patient had a distinct rise in temperature about the time the tubes came away, sometimes lasting for 2 or 3 days. Twice slight chills occurred at this time with fever. In two instances, pain was noted in one kidney while the tubes were in, despite the fact that the kidney was discharging clear urine. In both instances, this passed off without any serious consequences. In one instance, Case 2, in which an assistant punctured the right side of the sigmoid with the sigmoidoscope, a certain amount of local infection took place. In this case, quite a severe and prolonged fever followed after the tenth day with definite pain in the region of the right kidney. This was thought to have been due to an infection in the neighborhood of the right implantation which was made near the point where the puncture had been sutured. After the beginning of the third week, the patients recuperate very rapidly and so far we have had no evidence at all of late involvement of the kidney.

CASE 1. A baby boy, 20 months old, referred by Dr. John Hoyt of Spokane, Washington, had exstrophy of the bladder with small ulcers over the exposed mucosa. He had a temperature of 100 degrees on admission to the hospital. Bilateral transplantation of the ureters was carried out on February 12, 1927, No. 8 whistle tip ureteral catheters being used. The ureters were dilated and thickened. A small rubber tissue drain was placed in the lower angle of the wound outside of the peritoneum. On the fourth day after operation, the flow from the catheters ceased. After the patient had been given an anæsthetic, the catheters were cut loose from their anchors. Definite ridges and nipple-like protrusions marked the opening from the two ureters. On the eighth day after operation, the patient began to develop fever. On the twelfth postoperative day, the fever was very high and lasted for about 5 days, then gradually diminished. No further trouble was noticed. The last report, 1 year after operation, showed that the patient had not had any trouble as a result of the operation and was in perfect health.

CASE 2. A female, age 38 years, had a hopelessly incurable carcinoma of the vagina and bladder, which originated in the cervix. Bilateral transplantation of the ureters was carried out on February 22, 1928. No. 10 catheters were used. These were removed on the tenth postoperative day, a piece of dead ureter coming with each tube. The bladder was entirely relieved and the kidneys functioned perfectly. They were delivering urine into the rectum without distress 6½ months after operation although the growth was constantly spreading in the broad ligaments in spite of the heavy doses of radium which were used.

CASE 3. On April 4, 1928, a 15-year-old boy was operated upon at the Doernbecher Hospital, Portland, Oregon, in association with Dr. W. H. Bueermann, for exstrophy of the bladder. No. 12 ureteral catheters were used. The rectum was accidentally punctured by the sigmoidoscope, and the wound was sutured within the abdomen. Transplantation of the right ureter was made above the puncture; that of the left ureter below the puncture. The patient did well until the tenth day. On the eleventh

day, his temperature rose and the catheters were removed. The temperature continued intermittently for 3 weeks or more and was accompanied by pain in the right kidney. This finally subsided and the boy was in perfect health as far as could be determined. Five months after the operation the child was reported as being entirely well and attending school.

CASE 4. A female, 39 years of age, referred by Dr. A. F. Walter Kresse of Medford, Oregon, had an incurable vesicovaginal fistula after many operations attempted for relief. Bilateral transplantation was carried out on April 10, 1928. The bladder was found to consist chiefly of scar tissue. No. 12 ureteral catheters were used. The ureters were thin and dilated to the size of a small finger. The left catheter came away on the fifth postoperative day; the right began to close on the sixth postoperative day. After the end of the catheter had been cut off, the urine began to flow. The catheter was again cut off on the seventh day. On the eighth day leakage began around it. The catheter and an inch of dead ureter came away on the tenth day. Patient was entirely well 5 months after operation with no inconvenience from the urine in the rectum.

CASE 5. A female, 54 years of age, had a recurrent carcinoma of the bladder, following fulguration and radium treatment a year before. Bilateral transplantation of the ureters was carried out on July 3, 1928. No. 12 catheters were used and both were removed on the twelfth day. Recovery was uneventful. The patient was entirely comfortable with urine discharging into the rectum. Total cystectomy, September 3, 1928.

CASE 6. A male, 28 years of age, referred by Dr. John G. Cheetham of Portland, Oregon, had an advanced carcinoma of the bladder and was in a serious condition. Hæmoglobin was only 36 per cent and 3 blood transfusions were necessary during the course of the patient's stay in the hospital. The cancer was so far advanced, that the case was pronounced as hopeless. The bladder had been opened 2 months before to give temporary relief from pain. The cancer mass was sloughing and was very offensive. Bilateral transplantation was carried out on August 3, 1928. Both ureters were dilated. No. 12 ureteral catheters were used and a quarantine drain was placed at the lower angle of the wound. The ureters were blocked on the fifth day. The left ureter loosened on the fifth day and the right ureter also was apparently leaking. The left catheter came away easily, but the right catheter required some force, a small irregular piece of ureter coming away with the catheter. Leakage resulted above the transplantation and did not entirely heal. Heavy doses of radium were used in the bladder and at present the patient is up and rapidly improving in general health.

CASE 7. A male, 49 years of age, referred by Dr. J. T. Whitty of Seattle, Washington, had an advanced carcinoma of the bladder which had been removed at one time and treated by fulguration several times. On August 4, 1928, bilateral transplantation of the ureters was carried out and No. 12 catheters were used. The bladder was found to be filled with a cancerous mass. The ureters were large and thick. Along the right ureter were very large metastatic glands both in the pelvis and above the psoas muscle. The patient made an uninterrupted recovery and has had radium treatment for the cancer of the bladder, although the metastatic glands make the case hopeless as far as cure is concerned. The catheters worked perfectly and came away without force on the sixteenth postoperative day. No discomfort results from urine in the rectum. The patient is entirely comfortable and is gaining rapidly.

CASE 8. A female, 54 years old, referred by Dr. Charles C. Kehl, of Seattle, Washington, had a carcinoma of the bladder which had been treated a number of times with fulguration and finally abandoned as hopeless. Bilateral transplantation, with the use of No. 12 catheters, was carried out on August 20, 1928. The ureters were thick and somewhat dilated. Extensive involvement of the lymphatic glands along the course of the ureters was noted both in the pelvis and above the psoas muscle. I was informed by Dr. Kehl that the original growth was principally on the right side. Both catheters were removed on the eleventh postoperative day, as shown by the temperature chart. No evidence of infection of any kind was found. The patient made an uninterrupted recovery with little distress.

CASE 9. A female, 33 years of age, referred by Dr. W. E. Cass of Vancouver, Washington, had been given large doses of radium for an advanced cancer of the cervix and bladder. This had been followed by the formation of a vesicovaginal fistula and great distortion of the bladder by scar tissue. The bladder was very painful and had no capacity whatsoever. Bilateral transplantation of the ureters was carried out on August 25, 1928. No. 12, whistle tip, ureteral catheters were used. The right ureter was dilated to the size of a man's little finger and the wall was very thin. The left ureter was slightly dilated and thick. The patient was given a blood transfusion of 700 cubic centimeters following the operation. On the ninth postoperative day the right catheter was blocked by incrustation. This was relieved by a bulb-pointed stylette which was devised by Dr. Paul E. Spangler and which was made by braising a bulb on a piano wire (Fig. 22 C). The left catheter was removed on the eighth postoperative day. The right catheter came away of itself on the thirteenth day.

The temperature chart of the 9 cases (Fig. 24) shows the temperature for 30 days. Only 1 patient (Case 3) had fever after that time.

RÉSUMÉ

The valve principle is a fundamental necessity in the transmission of fluid at a given

temperature from a chamber of low pressure into one of higher pressure. A true automatic valve must be non-motile and yet movable. The valves of the heart, in the veins, at the outlet of the ureter, and at the outlet of the bile duct are true automatic valves. The muscular development near the outlet of the bile duct and the ureter has no control over the valves. The muscular structure along the wall of the duct and at its outlet probably regulates and accelerates the intermittent flow of bile or urine through the automatic valve and into the receiving viscus. The valve automatically closes in order to prevent reflux during the intermission of the delivery of fluid.

Intra-intestinal pressure varies in relation to intestinal peristalsis, being reduced in the wake of a peristaltic wave. This reduction of pressure facilitates the delivery of fluid through a duct emptying into this area.

Isolated instances of successful transplantation of ureters into the large bowel have been reported in the literature from time to time since the beginning of modern surgery. There is no one way of accounting for these successes inasmuch as few postmortem examinations, if any, have been held on successful cases. A certain amount of sustained success followed the Maydl operation improved by Moynihan's modification, also the Peters operation. In these cases, the ureter-bearing area of the bladder with the valve mechanism was transplanted with the ureter. A review of the literature in the Surgeon General's Library in 1910 showed approximately 250 articles dealing with experimental attempts to transplant the ureters. In no instance was there scientific evidence to show that success had been attained.

The experimentation by Franklin H. Martin was the most important that had been done. He actually approached and almost solved the problem. He devised a good technique but missed the goal of his ambition by failing to differentiate and separate the function of a sphincter from that of a valve. Clinically Fowler had actually made a valve, but failed to recognize it and therefore failed to elaborate it because the problem itself had not yet been isolated and defined.

The problem itself is to deliver fluid from a duct of an organ which works under low pressure into a receptacle where the pressure is higher. This problem was discovered in 1909 when it was found that a bile duct always dilated when transplanted into the duodenum without valve protection, wheras such transplanted duct did not dilate when protected by a valve. The principles and the technique used in the transplantation of the bile duct were adapted to the transplantation of the ureter into the large intestine with the result that in 1910, 5 undamaged dog kidneys and undilated ureters in which transplantation had been done at varying periods of 60 to 167 days prior to removal of the specimens, were presented to the surgical section of the American Medical Association along with a definite technique. Dr. Charles Mayo, who was chairman of the section, recognized the importance of the presentation and was the first to adopt the principles and apply them to a human patient. The published record of his work, set forth in papers dealing with his results on this subject, marks a new era in urological surgery. These records show that with great regularity and with relatively low mortality when compared with former statistics, he has been successful in transplanting the ureters at separate operations, in children with exstrophy of the bladder, and furthermore that these children grow and develop to maturity in a normal manner with relatively no evidence of late kidney damage. In other words, he has definitely proved that in those patients surviving the operation the membraneous valve formed by the operation is ample to protect the kidney.

A recent questionnaire brings the information that not only Lower and myself but many other surgeons, have been successful in a similar, though smaller, way but have not published the results. The reports also reveal many unpublished disastrous results. Pooling the good and bad results, the outlook has not been roseate. The necessity of two operations, each with a high average operative mortality, has with rare exception limited the field of the operation to exstrophy of the bladder which could be performed only by those surgeons especially trained and experienced. The two

major problems standing in the way of general use of the operation, after the efficiency of the valve had been demonstrated, were:

1. To preserve uninterrupted kidney function while both ureters were being transplanted at the same operation.

2. To minimize infection which had been the cause of nearly all deaths regardless of the type of operation.

The closed-duct tube technique solved the first problem, but infection, the chief cause of operative mortality, still remained. If the lower segment of the large bowel is segregated, it can, by irrigation and dry gauze packing, be made relatively clean and dry. By retroperitoneal drains, protected from contact with intestines by a quarantine or rubber tissue, practically all danger from sepsis is dispelled and the operation seems to be as free from danger as the average major abdominal operation. Proof is offered in a report of the first 9 consecutive cases operated upon by the technique herein described: two of the operations were for exstrophy of the bladder, 1 for incurable vesicovaginal fistula, 6 for advanced carcinoma of the bladder. There were no fatalities or near fatalities; there was one ureteral leak due to too much force being used when the catheter was removed; one ascending infection of right kidney due to accidental puncture of the sigmoid with the sigmoidoscope. The patient with the kidney infection finally recovered, and became a perfectly healthy boy. In all cases, renal function has seemingly been undiminished, the rectal function in the control of urine has been satisfactory, and there has been no evidence of kidney disturbance after convalescence.

Since the establishment of this technique, I have for the first time felt justified in recommending this operation for general use in cancer and maladies other than exstrophy of the bladder. I have in past communications expressed the hope that we would at some time perfect a technique which would be safe enough to justify such recommendation. I think we may confidently state that not only the problem, but the technique, has been solved and that we may now safely recommend the operation to skilled abdominal surgeons, whether urologists, gynecologists, or general surgeons, in the following cases:

1. Incurable carcinoma of the bladder, urethra, or prostate for palliative purposes.

2. Advanced carcinoma of the bladder, urethra, or prostate in which it is impossible surgically to remove the growth, but in which it is possible with the use of large and even ruthless doses of radium to destroy the growth.

3. Early curable carcinoma as an essential part of the operation of total cystectomy, which may include prostatectomy in the male or hysterectomy in the female.

4. Carcinoma involving the urethra.

5. Incurable vesicovaginal fistula.

6. Contracted bladder due to scars of ulceration or to other causes.

7. Extensive, incurable, multiple perineal fistulæ resulting from various causes.

8. Tuberculous ulceration of the bladder in which one kidney remains good, the other to be removed.

9. Traumatic injuries which make the use of the bladder impracticable.

10. Exstrophy of the bladder.

To summarize the indications, the operation may be considered justifiable in any condition in which it is necessary to dispense with the bladder as a reservoir for urine.

NOTE.—The No. 12 whistle tip catheters with Spangler stylet can be obtained from C. R. Bard, Inc., New York.

CRANIAL AND INTRACRANIAL DAMAGE IN THE NEWBORN[1]

An End-Result Study of One Hundred Seventeen Cases

By DONALD MUNRO, M.D., F.A.C.S., Boston

CRANIAL and intracranial damage in the newborn, commonly referred to as intracranial hæmorrhage in the newborn, has been subjected to sporadic investigation for many years. This has included postmortem examinations, large numbers of isolated case reports, and various recommendations as to therapeusis. However, a report of a sufficiently large series followed for a long enough time to yield reliable evidence as to the ultimate results of any one method of treatment has never been published. Past studies in etiology and diagnosis have also been largely speculative and lacking in the authority that comes from carefully studied clinical material of sufficient mass.

This paper presents the end-results of work carried on for the past 7 years on 117 cases. In addition, considerable data has been collected concerning the etiology, symptomatology, pathology, and treatment. This, however, must be reserved for future presentation except for certain high spots which help to clarify the material under immediate consideration.

TABLE I.—CLINICAL AND MISCELLANEOUS DIAGNOSES

Clinical diagnoses	Living	Dead	Total
Traumatic hæmorrhage	34	31	65
Hæmorrhagic disease hæmorrhage	3	13	16
Asphyxial hæmorrhage	10	6	16
Cerebral œdema, acute	11	7	18
Surgical shock	15	16	31
Fracture of skull	7	0	7
Fracture of clavicle	1	0	1
Brachial palsy	6	1	7
Lacerated brain	1	0	1
Meningismus	7	2	9
Spinal injury	0	1	1
Meningitis Fetal	0	1	1
Meningitis Acquired	1	2	3
Miscellaneous diagnoses			
Hæmorrhagic disease, extracranial	6	1	7
Prematurity	0	3	3
Stillborn	0	2	2
Hydrocephalus	2	2	4
Epilepsy and status epilepticus	1	1	2
Status thymicolymphaticus	0	1	1
Congenital syphilis	1	0	1
Congenital heart disease	1	1	2
Congenital dilatation of colon	1	0	1
Rickets	1	0	1
Infected wound	0	2	2
Abscess of neck	1	0	1
Needle perforation of sagittal sinus	1	0	1

CLASSIFICATION

The cases have been divided into three groups. This was first suggested in a paper published by the writer and R. S. Eustis in the *American Journal of Diseases of Children* in October, 1922. Except for certain modifications as to relative importance, that plan still proves satisfactory. In addition, the older diagnosis—intracranial hæmorrhage in the newborn—has had to be expanded to include certain types of brain and skull injuries, not previously covered, that may prove fatal or

TABLE II.—NUMBER OF PREGNANCY

Para	Living	Dead	Total
1	29	25	54
2	8	8	16
3	6	6	12
4	5	4	9
5	2	2	4
6	2	3	5
7	1	1	2
8	1	4	5
9	1		1
11	1		1
12		1	1
13	1		1
14		1	1
Not given	1	4	5

TABLE III.—SYMPTOMATOLOGY ANALYSIS

	Living	Dead	Total
Important symptoms			
Poor cry	44	44	88
Hypertonic	51	39	90
Cyanosis	35	42	77
Would not nurse	36	36	72
Tense fontanel	30	34	64
Apathetic	22	35	57
Abnormal respiration	15	31	46
Symptoms in 10 to 25 cases			
Flaccidity	10	18	28
Birth asphyxia	8	15	23
External hæmorrhage	7	13	20
Irritable central nervous system	22	9	31
Nystagmus	17	9	26
Cranial nerve involvement	11	11	22
Pallor	11	24	35
Jaundice	9	3	12
Dryness	11	8	19
Cephalhæmatoma	5	5	10

[1] Read before the Southern Surgical Association, December 13, 1927.

TABLE IV.—LUMBAR PUNCTURE DATA

	Living	Dead	Tota
Pressure data			
Number of cases punctured	56	39	95
Number of punctures made	99	50	149
Number of measurements taken	91	48	139
Highest pressure read	50 mm.	48 mm.	
Lowest pressure read	—1 mm.	—1 mm.	
Average pressure reading.	10.9 mm.	11.1 mm.	
Cerebrospinal fluid data			
Bloody fluid—living, 37; dead, 31			
Greatest amount	19 c.cm.	10 c.cm.	
Smallest amount	¼ c.cm.	½ c.cm.	
Average amount	4.2 c.cm.	3.7 c.cm.	
Number of amounts measured	20	22	42
Clear fluid — living, 12; dead, 1			
Greatest amount	25 c.cm.		
Smallest amount	¼ c.cm.		
Average amount	10.96 c.cm.		
Number of amounts measured	7	0	7
Yellow fluid—living, 24; dead, 10			
Greatest amount	17 c.cm.	4 c.cm.	
Smallest amount	⅓ c.cm.	½ c.cm.	
Average amount	6.9 c.cm.	3.75 c.cm.	
Number of amounts measured	18	6	24
Contaminated bloody fluid—living, 16; dead, 4			
Greatest amount	3 c.cm.	1.5 c.cm.	
Smallest amount	⅓ c.cm.	1.5 c.cm.	
Average amount	1.11 c.cm.	1.5 c.cm.	
Number of amounts measured	7	1	8
No fluid removed in punctures in	10	4	14
Combined cerebrospinal fluid data			
Greatest amount	25 c.cm. (yellow)	10 c.cm. (bloody)	
Smallest amount	¼ c.cm. (bloody or clear)	⅓ c.cm. (bloody)	
Average amount	5.542 c.cm.	2.485 c.cm.	

Pressure measurements are given in millimeters of mercury.

at least disabling. Such cases have no hæmorrhage in or about the central nervous system; although they are due to the same etiological factors and present the same indications for treatment as does the hæmorrhage type.

This grouping of the cases is as follows: traumatic, asphyxial, and the systemic blood conditions including hæmorrhagic disease of the newborn, syphilis, etc. In this series, as shown in Table I, there are 83 traumatic, 16 asphyxial, and 16 hæmorrhagic disease cases

Fig. 1. A case of traumatic hæmorrhage and surgical shock. This child, a second baby, was pale, cyanosed, and flaccid at birth. Nystagmus was present. One lumbar puncture was made which gave relief of intracranial hypertension. Death from rupture of the lateral sinus occurred 37 hours after birth. Case 47.

including 1 syphilitic case. The fractures and acute cerebral œdema cases when not already so diagnosed have been included among the traumatic groups. Certain entries appear twice in the tables. This is due, in part, to the fact that the hæmorrhage in the diathesis series is primarily from a rupture of some cerebral vessel caused either by trauma or asphyxia, which has failed to close normally because of the peculiar changes in the blood as evidenced by prolonged clotting and bleeding times.

DIAGNOSIS

The diagnosis depends, in the final analysis, on the demonstration of an increased intracranial pressure. This is true no matter what the type of case except when the patient is suffering from "surgical shock," or, as it is called in the older publications, "pallid

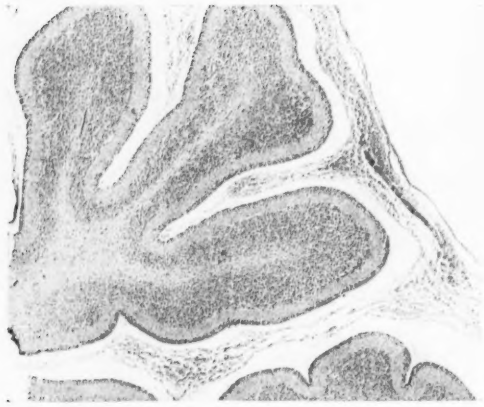

Fig. 2. A case of traumatic hæmorrhage in a first baby. Labor lasted for 37 hours. The child was hypertonic, cyanosed, pale, and unconscious. The fontanel bulged. Lumbar puncture showed a normal intracranial pressure. Death in 48 hours was due to cerebellar subarachnoid hæmorrhage and rupture of the straight sinus. Case 38.

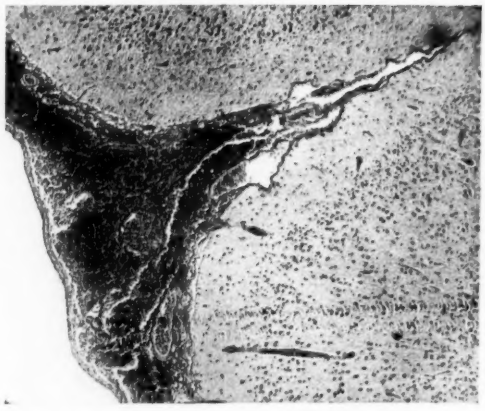

Fig. 3. A case of asphyxial hæmorrhage and surgical shock in a first baby. Induced labor with prolapse of cord and one hand. At birth, the child was pale, flaccid, and not breathing; at 24 hours, cyanosed and unconscious with irregular respiration. One lumbar puncture showed high normal intracranial tension. The child died on the fifth day of cerebral subarachnoid hæmorrhage with no meningeal damage. Case 54.

TABLE V.—GROSS AUTOPSY ANALYSIS OF INTRACRANIAL DAMAGE

	Total	Traumatic	Asphyxia	Hæmorrhagic disease	Cerebral œdema
Cerebral pathology					
Œdema	14	5	3	0	6
Congestion	9	3	3	1	2
Anæmia	2	1	0	0	1
Softening	3	1	0	2	0
Hæmorrhage (34 cases)					
Extradural	3	2	0	0	1
Subdural	5	4	0	1	0
Subarachnoid	13	12	0	1	0
Subpial	6	5	1	0	0
Ventricular	4	2	0	2	0
Intracortical	3	2	0	1	0
Not given	6	3	0	3	0
Cerebellar and brain stem pathology					
Œdema	1	1	0	0	0
Congestion	3	1	0	0	2
Softening	1	1	0	0	0
Hæmorrhage (14 cases)					
Extradural	0	0	0	0	0
Subdural	1	0	0	1	0
Subarachnoid	9	6	0	3	0
Subpial	3	3	0	0	0
Ventricular	1	1	0	0	0
Not given	7	5	0	2	0
Demonstrable vascular ruptures					
Vein of Galen	10	9	0	1	0
Superior sagittal sinus	3	3	0	0	0
Straight sinus	3	3	0	0	0
Petrosal sinus	2	1	0	0	1
Lateral sinus					
Left	7	6	0	0	1
Right	3	1	1	0	1
Bilateral	3	3	0	0	0

asphyxia." Massive meningeal hæmorrhage, multiple intracortical hæmorrhages, depressed fracture, or cerebral œdema all produce a definite measurable increase in intracranial pressure. Other symptoms are suggestive but

TABLE VI.—GROSS AUTOPSY ANALYSIS OF MISCELLANEOUS DAMAGE

	Total	Traumatic	Asphyxia	Hæmorrhagic disease	Cerebral œdema
Meningeal damage — hæmorrhages, tears, partial rupture or destruction, perforations and shredding					
Falx	20	12	3	0	5
Tentorium	24	16	3	1	4
Fracture of bone					
Skull	1	1	0	0	0
Spine	1	1	0	0	0
Extracranial hæmorrhage					
Scalp	3	2	0	1	0
Subperiosteal	8	4	0	1	3
Miscellaneous	7				
Hydrocephalus—4 cases					
Acute	..	1	0	1	1
Acquired	..	1	0	0	0
Meningitis—3 cases					
Fetal	..	1	0	0	0
Fresh	..	1	0	0	0
Old	..	1	0	0	0
General headings					
Secondary anæmia	5	3	0	2	0
Congenital anomalies	4	2	0	1	1
Total autopsies done	45	26	6	6	7
Total autopsies not done	11	4	0	7	0

TABLE VII.—GROSS AUTOPSY ANALYSIS OF EXTRACEREBRAL DAMAGE

	Total	Traumatic	Asphyxia	Hemorrhagic disease	Cerebral œdema
Thymus	5				
Large	..	3	0	0	1
Hæmorrhage	..	1	0	0	0
Mediastinum	1				
Hæmorrhage	..	1	0	0	0
Pleura	2				
Hæmorrhage	..	0	1	0	1
Lungs	13				
Rupture	..	1	0	0	0
Collapse	..	2	0	0	0
Congestion	..	5	0	1	3
Pneumonia	..	0	1	0	0
Pericardium	2				
Hæmorrhage	..	0	1	0	1
Heart	4				
Hæmorrhage	..	2	0	0	0
Anomaly	..	1	0	0	1
Stomach	1				
Acute dilatation		0	1	0	0
Intestine	3				
Hæmorrhage		1	0	0	0
Spasm		0	1	0	0
Anomaly		0	0	1	0
Liver	14				
Hæmorrhage		0	0	2	0
Congestion		6	2	0	3
Large		0	0	0	1
Spleen	6				
Congestion		4	1	0	1
Kidneys and ureter	3				
Hæmorrhage		1	0	0	0
Congestion		0	0	0	1
Anomaly		1	0	0	0
Adrenals	8				
Hæmorrhage		4	2	1	1
Omentum	1				
Hæmorrhage		0	0	1	0
Pelvis	2				
Hæmorrhage		1	0	1	0
Muscles	2				
Hæmorrhage		2	0	0	0
Ascites	1	1	0	0	0
Hernia	1				
Congenital		1	0	0	0

may be misleading. They may be summed up as follows (Tables II and III) on the basis of having been present 40 or more times either alone or in combination: a first baby, which is hypertonic, cyanosed, refuses to nurse from the breast or bottle, has a tense anterior fontanel, is apathetic, and has some respiratory abnormality may be presumed to be suffering from an intracranial injury.

TREATMENT

Treatment has been based on three fundamental procedures. No active measures were knowingly carried out until the patient had recovered from the surgical shock. In the traumatic and asphyxial groups, lumbar decompression with a manometer has been performed as soon after the end of the shock period as possible, and continued until the cerebrospinal fluid pressure level has again become fixed at normal. In the hæmorrhagic disease group, parental whole blood has been given intramuscularly in 30-cubic centimeter doses every 3 hours for 4 doses. This has been repeated at the end of another 12 hours as often as might be necessary to bring the bleeding and clotting times to normal, after which lumbar decompression has been started. Depressed fractures were elevated as soon as possible in every case. In addition the babies were left in the hospital under close observation for at least 2 weeks from the day that the cerebrospinal fluid pressure was found to be normal (Table IV). Certain other details which are concerned with the nursing, fluid intake, handling, feeding, and the treatment of a secondary serous meningitic condition which occurs at the end of the second week, can not be discussed at the present time.

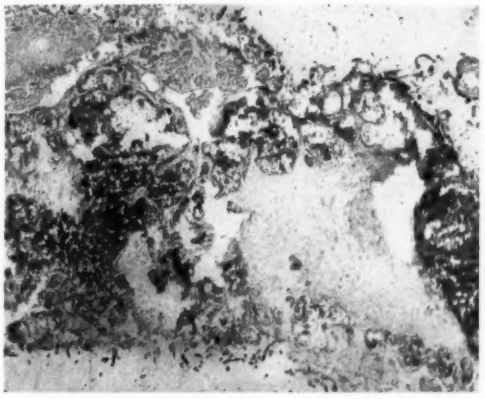

Fig. 4. A case of traumatic hæmorrhage in a third baby. At birth the child had a cephalhæmatoma of the entire scalp, hypertonus, a tense fontanel, and labored respiration and was pale. One lumbar puncture gave relief of intracranial hypertension and resulted in an improvement of the symptoms for 5 hours. At 36 hours, there was a sudden recurrence and death, due to a choroid plexus hæmorrhage and congestion—old and new, fracture of the skull, and rupture of the vein of Galen and the left lateral sinus. Case 55.

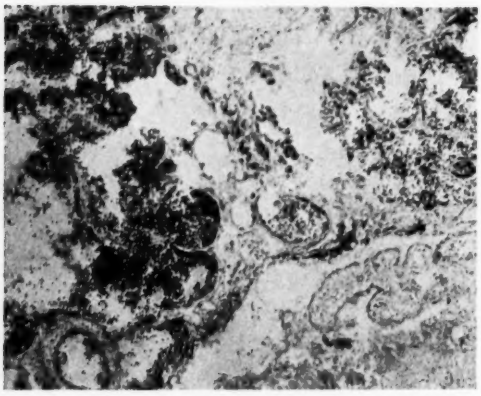

Fig. 5. The same case as shown in Figure 4 with photomicrograph taken under higher magnification.

Fig. 6. A case of asphyxial hæmorrhage in a first baby. At birth the child was cyanosed and asphyxiated. At 43 hours, there was respiratory difficulty, bulging of the fontanel, cyanosis, hypertonus, left external rectus palsy, and nystagmus. One lumbar puncture gave relief of intracranial hypertension. At the age of 45 hours, the child died of respiratory paralysis. Medullary hæmorrhage into the cuneate nucleus was found but no meningeal damage. Case 11.

FATAL CASES

The end-results in the fatal cases have been obtained insofar as possible from both a gross and microscopic study of postmortem material. The microscopic examination of the central nervous system has been carried out in every instance by Dr. Stanley Cobb, but for whose kindly assistance this work would have been largely impossible. There were 56 primarily fatal cases. Of these 45 came to autopsy. Microscopic studies of the brain were made in 23 cases.

As will be seen from Table V, hæmorrhage, œdema, and congestion are the outstanding gross central nervous system pathological entities with hæmorrhage appearing 48 times. Twenty-two or almost half of these hæmorrhages were subarachnoid in location. Hæmorrhage typically appeared in the traumatic class of case (Fig. 1). It was conspicuous by its absence in the asphyxial and cerebral œdema classes, appearing only once in these. Associated with the hæmorrhage, we find some degree of laceration of the falx and tentorium in 44 instances (Table VI). The source of the hæmorrhage was, in the large majority, either from the great vein of Galen or from one or both of the lateral sinuses. Twenty-three of the 31 that could be identified occurred in one or the other of these two places. The superior sagittal, the straight, and the petrosal sinuses were all about equally involved and were very much in the minority.

Meningitis was found 3 times. The most interesting of these cases was one in which the infant lived only 1½ hours after delivery but nevertheless presented an old, well organized

TABLE VIII.—MICROSCOPIC ANALYSIS OF CEREBRAL DAMAGE

	Total	Traumatic	Asphyxia	Hæmorrhagic disease	Cerebral œdema
Intracortical lesions					
Congestion	14	10	3	0	1
Hæmorrhage	14	9	3	1	1
Œdema	13	9	2	1	1
Cellular changes	6	6	0	0	0
Lymphocytic reaction	3	2	1	0	0
Choroid plexus lesions					
Congestion	3	1	2	0	0
Hæmorrhage	2	1	1	0	0
Lymphocytic reaction	1	1	0	0	0
Meningeal lesions					
Hæmorrhage					
Subpial	7	3	1	2	1
Subarachnoid	11	8	1	2	0
Subdural	1	0	0	1	0
Ventricular	1	1	0	0	0
Congestion					
Subpial	4	1	2	1	0
Subarachnoid	0	0	0	0	0
Subdural	0	0	0	0	0
Microscopic examination	23	15	3	3	2
No microscopic examination	22	11	3	3	5

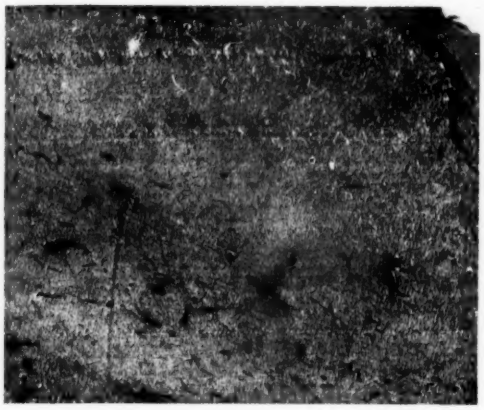

Fig. 7. A case of traumatic hæmorrhage and surgical shock in a first baby. The child was flaccid and pale at birth with fracture of the clavicle. On the second day, there was hypertonus with convulsions, cyanosis, nystagmus, and a tense fontanel. One lumbar puncture gave relief of the high intracranial tension. The child died at the age of 51 hours. Postmortem examination showed extreme intracortical congestion, œdema, and softening of the cerebrum with rupture of the falx and tentorium and right inferior petrosal sinus. Case 53.

Fig. 8. Same case as that shown in Figure 3 showing marked perivascular and perineural œdema.

meningitis which must have been present a number of weeks. The gross lesions in the rest of the organs have no particular significance except that the liver, lungs, and adrenals showed the most constant damage (Table VII). Microscopically in the brain, we again

TABLE IX.—FOLLOW-UP OF THE NON-FATAL CASES

Age when last seen	Normal December, 1927	Normal when lost at date given	Living but diseased December, 1927	Lost at discharge
Over 6 years	2			
5½ to 6 yrs.	9			
5 to 5½ yrs.	1			
4½ to 5 yrs.	3			
4 to 4½ yrs.	1			
3½ to 4 yrs.	4			
2½ to 3 yrs.	2	2	1 Occasional convulsion	
2 to 2½ yrs.			1 Hydrocephalic idiot	
1½ to 2 yrs.			1 Hydrocephalic epileptic	
1 to 1½ yrs.	1	4		
6 mo. to 1 yr.	2	3		
Less than 6 mo.				
Total	25	9	3	10

TABLE IX A.—FOLLOW-UP OF CASES FATAL SINCE DISCHARGE

Age at death	Cause of death	Autopsy	Extracranial cause	Cranial cause
5 yrs., 7 mo.	Acute encephalitis following tonsillectomy	Yes	Yes	
1 yr., 9 mo.	Hydrocephalus and epilepsy	Yes		Yes
1 yr., 2 mo.	Colectomy for Hirschsprung's disease	No (Operation)	Yes	
11 months	Spastic idiot, erysipelas	No		Yes
6 months	Unknown	No	?	?
6 months	Congenital heart disease	No	Yes	
1 month	Unknown	No	?	?
1 month	Hydrocephalus and neglect	No		Yes
2 months	Congenital syphilis	Yes	Yes	
2 months	Hydrocephalus	Yes		Yes
1 month	Influenza	No	Yes	
Total	11		5	4

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 13.

Fig. 9. A case of asphyxial hæmorrhage in a first baby. The child was asphyxiated at birth. Two lumbar punctures gave relief of intracranial hypertension. Photograph taken when child was 2½ years old. Death from acute encephalitis occurred when child was 5½ years old. Case 111.

Fig. 10. A case of asphyxial hæmorrhage in a first baby. The child was asphyxiated at birth. Two lumbar punctures gave relief of intracranial hypertension. Photograph taken when child was 2 years and 3 months old. She was living and normal at 5 years and 9 months. Case 104.

Fig. 11. A case of traumatic hæmorrhage in a second baby. At birth there was cyanosis and hypertonus with nystagmus. One lumbar puncture gave relief of moderate intracranial hypertension. This photograph was taken when the child was 10 months old. She was living and normal at 1 year and 1 month. Case 112.

Fig. 13. A case of hæmorrhagic disease of the newborn, needle perforation of the superior sagittal sinus, traumatic hæmorrhage, and meningismus in a first baby. Labor lasted for 33 hours. At 48 hours, there was blood in the stools. Attempted transfusion resulted in perforation of the sinus. In 3 hours there was a left-sided convulsion. When 4½ days old, the child was hypertonic and stuporous, with a left hemiplegia, nystagmus, and tense fontanel. One lumbar puncture relieved the symptoms and intracranial hypertension. At 14 days, sudden cyanosis with convulsions appeared. Three lumbar punctures with the removal of 36 cubic centimeters of clear yellow cerebrospinal fluid relieved the secondary intracranial hypertension and other symptoms. This photograph was taken when the child was 6 months old; she was living and well at 3 years and 10 months. Case 125.

find that congestion, hæmorrhage, and œdema lead the list (Figs. 2 and 3). Again, too, the hæmorrhage is most commonly subarachnoid or intracortical, with the subpial location a good third (Table VIII). The choroid plexus alone may also be the seat of pathological changes (Figs. 4 and 5). Among the asphyxial cases it is significant that all 3 brains examined showed intracortical congestion and hæmorrhage extending in 2 cases to involvement of the choroid (Figs. 6, 7, 8).

END-RESULTS IN NON-FATAL CASES

Fifty-eight babies were discharged, relieved or improved, from the hospital. All but 10 of these have been followed up to December, 1927. Eleven of the remaining 48 died after discharge. Five of these 11 died from known extracranial causes at ages ranging from 5½ years to 1 month, all being normal from a cerebral point of view at the time of death (Fig. 9). There were 2 cases in which the cause of death could not be determined, 1 dying at 6 and the other at 1 month.

Four infants died on account of known cerebral disease. In addition there were three infants who were apparently normal on discharge from the hospital, but who have since developed cerebral symptoms. With 2 exceptions all of this type have shown a definite hydrocephalus either at autopsy or by enlargement of the head with persistently open fontanels. Of the 2 exceptions, 1 is living and normal in every way except that he has been

Fig. 12.

Fig. 14.

Fig. 15.

Fig. 12. A case of traumatic hæmorrhage, surgical shock, and meningismus in a first baby. After an excessively difficult delivery, the child was pallid and flaccid and not breathing. Twenty-four hours later, the child was hypertonic and cyanotic. The fontanel bulged, and there were generalized convulsions. One lumbar puncture gave relief from the intracranial hypertension. On the eighth day, the fontanel was again tense but there were no other signs. Two lumbar punctures relieved the secondary intracranial hypertension. This photograph was taken when the child was 3½ years old. She was living and normal at 5 years and 2 months. Case 117.

Fig. 14. A case of acute cerebral œdema and surgical shock in a first baby. After delivery the child was pale and flaccid and was not breathing. The pulse count was 40. At 3½ days, the child was cyanosed and hypertonic with a temperature of 106 degrees. He had a shrill, weak cry. One lumbar puncture with the removal of clear colorless cerebrospinal fluid relieved the mild intracranial hypertension. This photograph was taken when the child was 1½ years old. He was living and normal at 5 years and 11 months. Case 153.

Fig. 15. A case of traumatic hæmorrhage in a first baby. On the third day the child was cyanotic and had convulsions with a left external rectus palsy. One ventricular puncture and one lumbar puncture relieved the intracranial hypertension and other symptoms. This photograph was taken when the child was 4 years of age. She was living and normal when 5 years and 11 months old. Case 147.

having mild generalized convulsions about every 3 months for the past 2 years. These are becoming less severe and have left no demonstrable aftermath. The other was a spastic idiot at 3 months and remained so until he died of erysipelas at 11 months. Of the 5 others, 3 lived long enough to show symptoms of either epilepsy or idiocy in addition to the hydrocephalus, while 2, living for only 1 and 2 months respectively, showed only the underlying hydrocephalus. It is significant that in every case, except the 1 that is still living and only having convulsions, treatment was inadequate. Either no treatment at all was given after birth or that given was improperly carried out or not persisted in for a sufficient length of time, the babies being discharged in spite of the presence of symptoms.

Of the 34 patients still living and normal, 24 are over 2½ years of age at this time (Figs. 10 and 11). This is significant because, in this series, cerebral disease, when it has occurred, has been easily demonstrable within the first 2 years, and in every instance but 1 has actually been diagnosed within the first year of life (Figs. 12 and 13). The chances, therefore, favor the normal development of half of the 10 that fall in the groups below 1½ years. All three types are represented, although as shown in Table I, the hæmorrhagic disease group is in a very small minority (Figs. 14 and 15).

The most striking of all of the children (not included among the photographs) is now 6 years and 1 month of age. He goes to school and is normal in every way except for a residual sixth nerve palsy. At birth, however, this child at one time had an intracranial pressure of 50 millimeters of mercury which was relieved only by removing 90 cubic centimeters of cerebrospinal fluid from his ventricle. Three lumbar punctures and one ventricular puncture were made in a period of 3 weeks and approximately 120 cubic centime-

ters of cerebrospinal fluid were removed. It is obvious that such a degree of acute hydrocephalus as this predicates, would inevitably lead to a chronic dilatation without some such relief as has been described.

CONCLUSIONS

The end-results of a series of 117 cases of cranial and intracranial damage in the newborn collected and followed during the past 7 years are presented.

The diagnosis of intracranial hæmorrhage of the newborn must be expanded to include cerebral œdema and fracture of the skull, and should be stated as "cranial and intracranial damage in the newborn."

Postmortem gross and microscopic studies conducted on 45 of the 56 primarily fatal cases show that meningeal and intracortical hæmorrhage, congestion, and œdema are the most common pathological entities.

Gross intracranial hæmorrhage may occur from the rupture of most of the large venous sinuses, the most common sites being the great vein of Galen or the lateral sinus.

Intracortical œdema and congestion alone may cause death in the newborn.

Associated developmental anomalies and cerebral developmental defects were in the one case negligible and in the other absent in this series.

Forty-eight of the 58 babies discharged living and relieved have been followed up to December, 1927. Thirty-nine of the 48 may be classed as cured; 5 are still too young to allow for a satisfactory estimation of the end-result.

The most common late result of cerebral damage in the newborn is hydrocephalus associated with either epilepsy or idiocy. Convulsions alone and spasticity associated with idiocy have also occurred.

Active treatment in this series was limited to lumbar decompression after recovery from surgical shock. In addition, parental blood was given intramuscularly in the hæmorrhagic disease group. Depressed fractures were elevated as soon as possible. Ventricular puncture was done twice, as was a typical subtemporal decompression.

EXPERIMENTAL AND CLINICAL CONTRIBUTION TO THE QUESTION OF THE INNERVATION OF THE VESSELS

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From the Surgical Clinic of the University of Strasbourg

WITHOUT doubt surgery of the sympathetic system has contributed greatly to the study of the anatomy and physiology of the innervation of the vessels. Previous to 1913, when the senior writer performed the first periarterial sympathectomy, our knowledge of this particular subject was confined to the studies of Claude Bernard and the English school as represented by Langley and Gaskell. In accordance with the classical doctrine of the physiologists, Leriche explained the hyperæmia which he found following his operations upon the periarterial sympathetic as a consequence of the section of the centrifugal vasomotor fibers. But the fact that a unilateral sympathectomy often had a bilateral therapeutic result, as first seen by one of us (22), very soon aroused the opinion that this theory was erroneous. Consequently, the majority of surgeons who were interested in the surgery of the sympathetic system began to think that the hyperæmia following sympathectomies was more active than passive and due rather to section of the centripetal ascending, sensory fibers than to section of the centrifugal, descending, motor fibers.

Since then, many surgeons have tried to prove the existence of such sensory vascular fibers and in so doing have employed vastly different procedures. Several have undertaken anatomical research, reasoning that if, by the section of the sensory fibers contained in the adventitia of the femoral artery one can produce a hyperæmia of the foot, one should find in the periarterial sheath long nerve fibers. These they have attempted to dissect, but so far, no one has succeeded in finding such fibers. In spite of numerous recent studies, one is forced to conclude that our knowledge of the anatomy of the vascular nerves has not been markedly advanced since the well known work of Potts, and Kramer and Todd. These writers have shown that, with the exception of the iliac and axillary arteries which receive direct fibers from the sympathetic trunk, the innervation of the vessels is segmentary and comes from the adjacent spinal nerves. Such is also the conclusion derived from the more recent work of Odermatt, Wiedhopf, Hahn and Hunczek, and Ljetnick.

With such segmentary innervation, it becomes very difficult to understand the effect of periarterial sympathectomy even though Hirsch, who admits segmentary innervation of the vessels, shows that the nerves reach them in a direction which is parallel to the axis and that after reaching the adventitia the nerve fibers are distributed especially in the neighboring collaterals. Such being the case a periarterial sympathectomy would denervate the distal segment of the artery and its collaterals rather than the segment upon which the operation has been performed.

Other writers have studied the innervation of the vessels by the use of physiological experiments and have shown that the vessels are sensitive and that, by an intra-arterial injection of a 10 per cent solution of barium chloride or a 50 per cent solution of lactic acid one can cause acute pain. Pagano, and Friedrich and Hellwig think that the pain is produced in the intima of the arteries themselves, but Odermatt and more recently Dumpert and Flick claim that pain is produced only after the injected solution has reached the arterioles and capillaries.

In any event after section of the sensory nerves, an intra-arterial injection of lactic acid still produces pain (Friedrich) and such a section does not interfere with the vascular reflexes (Stewart and Laffer), but after a periarterial sympathectomy the injection becomes painless (Hellwig[1]).

We need not dwell longer on these physiological experiments which have been analyzed elsewhere and which were critically reviewed in Odermatt's paper. Here we shall

[1] This statement of Hellwig's is not accepted by Dumpert and Flick.

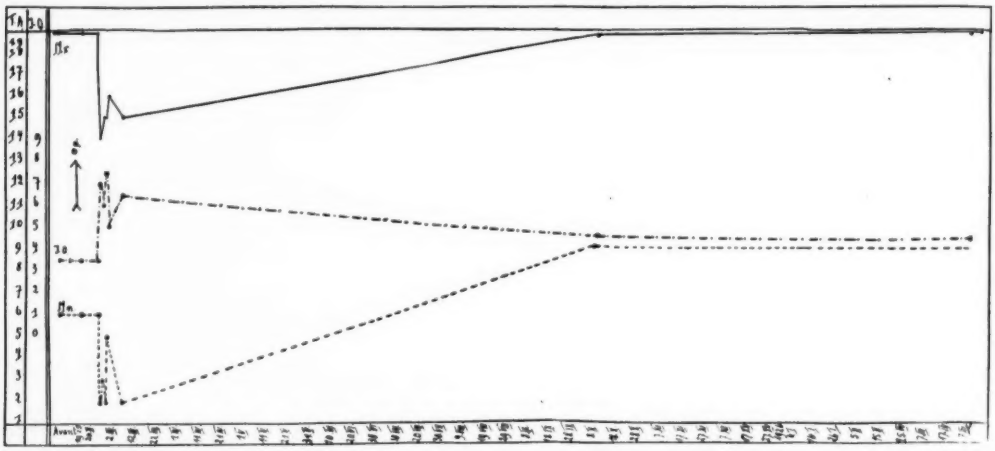

Fig. 1. Left side (operated upon). Mr. R. The entire left cervical chain except the stellate ganglion had been removed. Section of all the rami coming from the stellate ganglion (C_6, C_7, C_8, D_1) and of the roots of the vertebral nerve was also carried out. Figures 1 and 2 show the modifications of the blood pressure during the first year after intervention. The pressure was measured with the oscillometer on the lower third of the forearm with the *manchette de Pachon*. Soon after the operation *Mx* and *Mn* decreased considerably on both sides, whereas the oscillometric index (*I.O.*) increased in the same proportion. However, the normal balance was shortly re-established. The upper curve shows the modifications of the maximum blood pressure (*Mx*), the middle those of the oscillometric index (*I.O.*); and the lower one those of the minimum blood pressure (*Mn*).

limit ourselves to saying that the great majority of surgeons who have experimentally studied the innervation of the vessels believe that sensory fibers for them really exist. Wiedhopf and Langley alone, basing their opinion on contradictory studies on animals, deny the existence of such fibers.

The fact that a unilateral periarterial sympathectomy frequently has a therapeutic effect on both sides, that the deep sensation is conserved after the section of all cerebrospinal nerves (A. Thomas and Foerster), and that sympathectomy is successful in many painful syndromes are all proof of the existence of sensory nerves in the vessels. But just as it is true that many physiological and clinical facts cannot be explained by the old vasomotor theory, one must also concede that, up to the present, no sensory fibers have been anatomically demonstrated. This is why in recent years so many new theories concerning the innervation of the vessels have been advanced. In view of their anatomical research some authors still deny the existence of long sympathetic fibers, especially of sensory ones in the arterial adventitia, and so they fail to give a satisfactory explanation of the vascular changes which occur after sympathectomy. Other surgeons, who base their opinions upon such clinical and physiological experiments as we have previously mentioned, believe that the vessels have sensory fibers but have nevertheless frequently advanced opinions which have been in direct contradiction to the actual anatomical findings.

The theory which we offer does not disagree with the anatomy, although we cannot, at present, give the anatomical proofs of our statements. They are based entirely upon our observations on human beings and so avoid the criticism that what may be true with animals is not necessarily applicable to man.

After sympathectomy, whether a part of the trunk is removed or only the preganglionic or postganglic fibers are cut, vascular changes occur which cannot be explained by the classical theory of vasomotor activity. As we have elsewhere discussed these facts at length (25), we shall only mention them briefly. Besides the clinical findings which we have already mentioned, the most important points are as follows:

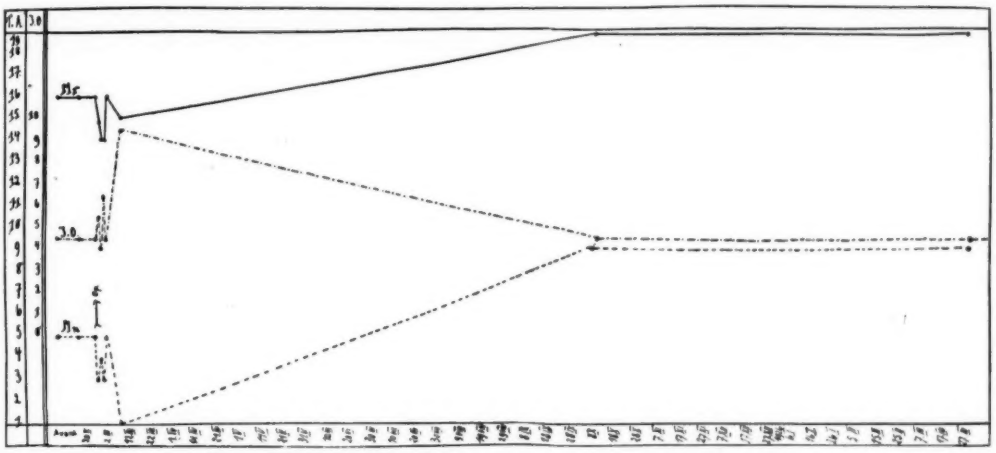

Fig. 2. Right side (intact). Same case as that recorded in Figure 1.

1. In man, after all operations upon the cervicothoracic sympathetic trunk, whether it is entirely removed or only the ablation of the superior or stellate ganglion is performed, or only the rami communicantes are cut, one observes at the level of the upper extremities, after a short period of increase in the arterial tension, a marked lowering of the maximum and minimum pressure while the oscillometric index remains increased. In a few weeks the arterial pressure again reaches its original level and the oscillometric index becomes stabilized at its normal figure. Sometimes the postoperative figures are a little below the pre-operative. So one may see that within a few weeks the effect of a sympathectomy upon the blood pressure in the leg affected by the operation disappears entirely.

2. If one is curious enough to examine the blood pressure in both legs at the same time one will find the same vascular changes in both with a parallel and simultaneous evolution. This is shown by the graphs of two cases. The blood pressure was regularly checked for one year and was measured with Dr. Pachon's instrument. The first patient, Mr. Rue. (Figs. 1 and 2), had the superior part of the cervical trunk down to a point above the stellate ganglion removed with a section of the rami communicantes of this ganglion. The second patient, Mrs. Mi., (Figs. 3 and 4), who was also operated upon for angina pectoris, had undergone a superior and inferior cervical ramisection on the left side. The vascular changes in both cases were bilateral but transitory. One year after the operation the blood pressure and the oscillometric index were the same as before operation.

3. The same vascular changes occur in the lower extremities after any operation upon the lumbar sympathetic trunk, and these also are bilateral.

4. Frequently following cervical or lumbar sympathectomy, modifications in the blood pressure are found in all four extremities. As proof of this statement we submit 4 graphs (Figs. 5, 6, 7, 8) which we obtained from a man 30 years of age, upon whom we performed a left lumbar ramisection for reflex disturbances in the left lower extremity. After the operation, this patient had the typical modifications of the maximum and minimum pressure and the oscillometric index in all four extremities. The pressure in the arterioles, measured with Gaertner's tonometer, showed the same changes everywhere. Five weeks later, all of these variations were found to have returned to the pre-operative rate.

5. Periarterial sympathectomy, frequently produces all of the signs of an active vasodilatation not only on the side operated upon but on both sides and often in all four extremities. Within a few weeks the circulation again becomes normal.

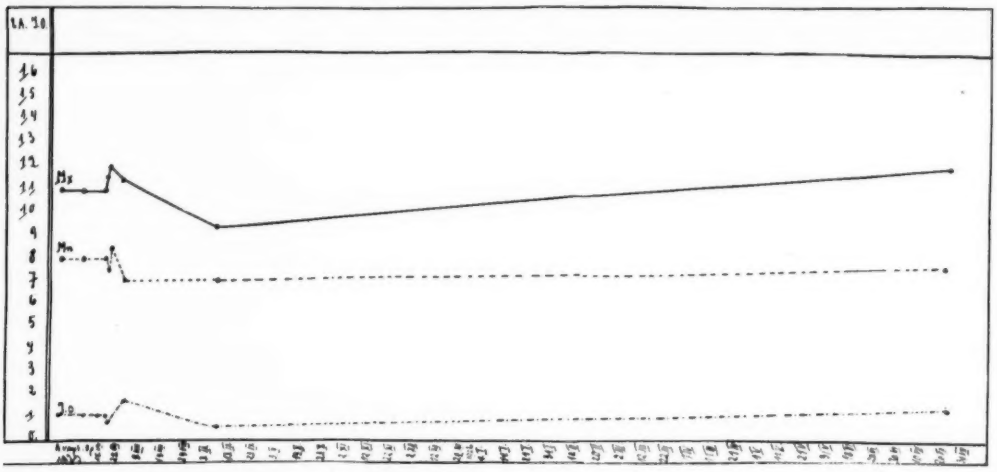

Fig. 3. Left side (operated upon). Mrs. M. Section of all the rami communicantes of the neck from second cervical to the first dorsal, inclusive, for angina pectoris. Figures 3 and 4 show the modifications of the blood pressure during the first year after the operation. *Mx* (upper curve) and *Mn* (middle curve) were determined on the arms by the auscultatory method and the oscillometric index (*I.O.*; the lower curve) on the forearms with the oscillometric method. The curves show the same variations on the operated left as on the intact right side. Shortly after the operation *Mx* and *Mn* decreased, whereas *I.O.* increased. However, the normal balance was soon regained.

6. The resection of an obliterated arterial trunk, acting in the same way as a periarterial sympathectomy, produces a vasodilatation with active local hyperæmia and hyperleucocytosis. This, too, returns more or less rapidly to normal.

7. In certain cases, namely Buerger's disease, in which one finds an obliterated venous trunk, the resection of this trunk also produces a temporary hyperæmia.

All of these facts cannot be explained by the classical theory of vasomotor activity; but they can be readily understood if one advances the hypothesis of sensory fibers in the vessels.

On the contrary, there are now certain other facts which seem to indicate that sympathectomy does really destroy motor fibers. The most important is the following: We know that Claude Bernard found that in animals the removal of the superior cervical ganglion produced a marked hyperæmia in the corresponding foreleg, which persisted over a period of 18 months following operation. In human beings, we have observed the same phenomenon after operations upon the cervical and, more often, upon the lumbar sympathetic. We found in these cases more than 1 or 2 years after operation a persistent elevation of the local temperature of the involved limb. The increase was 1, 2, 4 and, in one case, 7 degrees C. and, at the time of the last examination, when these figures were recorded, all other vascular changes due to the sympathectomy had disappeared.

The patient whose graphs are shown in Figures 5 to 8 represents a typical case. Six weeks after a left lumbar ramisection, the maximum and minimum pressure, the oscillometric index, and the pressure in the arterioles had returned to the pre-operative rate in all four extremities, but the left lower extremity still showed an increase of 2 degrees C. in its local temperature. Four months later this hyperæmia still persisted.

Adson, Brown, and Rowntree and Allen at the Mayo Clinic have made similar observations following lumbar ganglionectomies. These apparently indicate a vasomotor paralysis caused by the operation, and this would be completely in accord with the classical theory of vasomotor activity.

If one carefully observes the vascular changes following sympathectomies, one concludes that some results indicate that, while

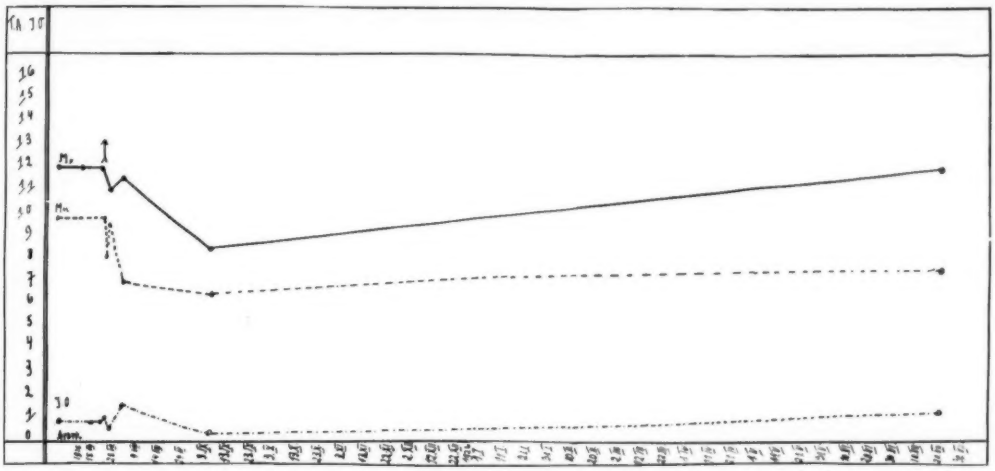

Fig. 4. Right side (intact). Same case as that recorded in Figure 3.

the operation has only a very transitory influence upon the circulation, other modifications are deeper and more persistent. This again brings up the question as to whether or not sympathectomy really produces a vasomotor paralysis.

We shall answer this by a study of the vascular reflexes. Our observations have been made on patients whom we have seen for recent or old traumatic nerve sections or upon whom we have performed therapeutic neurotomies. The section of the nerves in all of the patients was verified at the time of operation.

The best way to ascertain whether or not the section of the so-called vasomotor nerves produces a paralysis is to see if the blood vessels in the denervated area respond to excitations which normally produce either a contraction or dilatation of the arterial wall. Cold should instantaneously produce a marked vasoconstriction and heat a vasodilatation. If by sympathectomy one really interrupts the vasoconstrictors, the vessels should not be able to contract. On the other hand, if the spinal nerves really contain the vasodilatators, heat should no longer produce an increase of the blood supply when these nerves are cut. In other words, in either case the vessels should no longer be able to adapt themselves to external heat and cold.

We have studied these reactions by inscribing the oscillations, obtained with Dr. Pachon's instrument, upon a kymograph. First, we took the normal curve, then for 10 minutes the limb was put alternately in water at 40 degrees and at 0 degrees C. After each bath a new curve was taken and by comparing the results we were able to judge the reactions to external heat and cold. The following cases were examined.

I. *Six patients had at some time undergone sympathectomy.*

Case 1. Mrs. L. had had the left stellate ganglion removed for bronchial asthma 1½ years before.

Case 2. Mr. B. had had the left stellate ganglion removed for bronchial asthma 18 days before (Figs. 9 to 14).

Case 3. Mrs. S. had been operated upon 20 months before. She had had an inferior cervical ramisection performed for reflex disturbances in the upper extremity (Fig. 15).

Case 4. Mrs. T. had had a bilateral inferior cervical ramisection and a bilateral perihumeral sympathectomy for scleroderma performed 1½ years before.

Case 5. Mr. K. had had a left lumbar ramisection done for reflex disturbances in the left lower extremity.

Case 6. Mr. F. had had an inferior cervical ramisection for Raynaud's disease a few days before.

II. *Five patients had suffered traumatic sections of the spinal nerves:* In several cases the trauma was old, in the others more recent. These sections were verified by operation and two of these patients have also had sympathectomies performed.

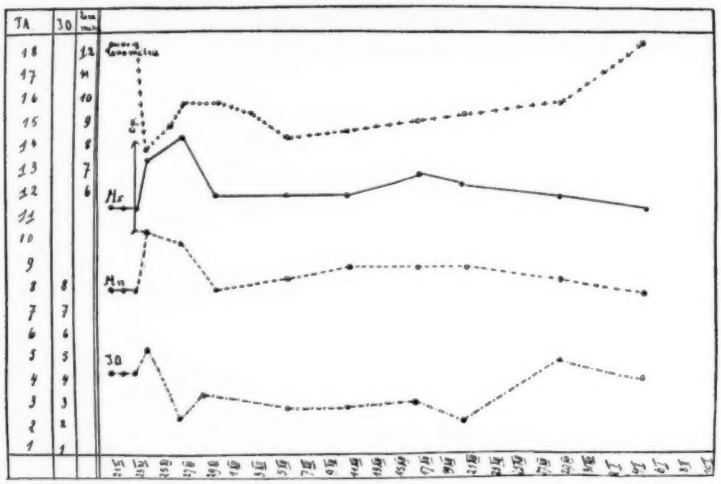

Fig. 5. Left upper extremity. Mr. Ko., 30 years of age, suffered from a post-traumatic reflex of the left leg. A left-sided lumbar ramisection to relieve the condition. The blood pressure of each of the extremities was measured daily for 1½ months. On the distal thirds of the legs, the pressure was measured by the oscillometric method. On the upper extremities the *Mx* and *Mn* were determined by the auscultatory method. The pressure in the arterioles was measured with the Gaertner tonometer. The local temperature was also recorded. Figures 5 and 6 show a marked increase of the *Mx* and *Mn* of the upper extremities during the first days following the operation, but normal conditions soon prevailed. The tonometric index decreased considerably following the operation and its return to the normal was slower than that of the other indices.——, *Mx*, indicates maximum blood pressure; – –, *Mn*, indicates minimum blood pressure; –·–, *I.O.*, indicates oscillometric index; ++ indicates tonometric index.

Case 1. Six months ago, Mr. N. had received a gunshot wound which involved the median nerve. Complete section.

Case 2. Mr. T. had had a complete section of the radial nerve in the lower third of the forearm 4 months before.

Case 3. Mr. L. was wounded during the war (1918) and had had a complete section of the sciatic nerve in the upper third of the thigh. Six years before examination a perifemoral sympathectomy had been performed for trophic ulcers and 18 months before, the limb was amputated at the middle of the calf.

Case 4. Mr. Z. had had a complete section of the sciatic nerve in 1916; a periarterial sympathectomy had been performed 2 years before and a lumbar ramisection 3 months before examination.

Case 5. Mr. F. had had a partial section of the brachial plexus (the fifth and sixth cervical roots) which produced a complete paralysis of the muscles of the arm and shoulder but conserved the motion of the fingers. This injury was received in an automobile accident 3 months before examination.

III. *Three patients had spinal cord lesions:*

Case 1. Mr. G. had had a complete traumatic section of the spinal cord at the level of the eighth dorsal vertebra. This has been verified by laminectomy. The accident dated back 4 months. Two months later a perifemoral sympathectomy had been performed on the right side.

Case 2. Mr. H. had a spasmodic quadriplegia after the fracture of several cervical vertebræ 5 months before. Laminectomy had been performed.

Case 3. Mr. S. had had a spinal cord syndrome of unknown origin, accompanied by marked vasomotor changes and a spontaneous right sided Claude Bernard-Horner syndrome which could not be explained by the compression of the cervical sympathetic and seemed to be of medullary origin.

In all of these 14 patients, the reactions to heat and cold were normal. The cold bath always produced a marked reduction in the amplitude of the oscillations which in hot water rapidly became normal and then increased in size. There may have been some difference in the intensity of the reactions depending upon the individual patient, but we found the same variations in a series of normal persons whom we examined in order to establish a control. This may be explained by the fact that all of our patients were not of the same age and, as is well known, older persons

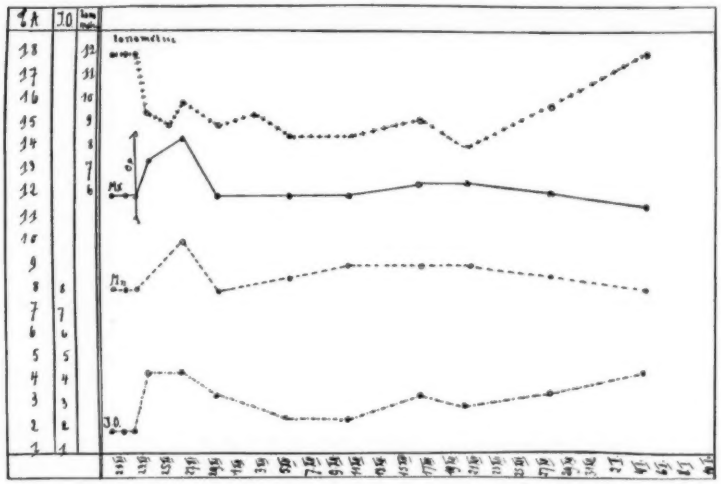

Fig. 6. Right upper extremity. Same case as that recorded in Figure 5.

have less extensible vessels than younger ones. We also know that the intensity of all nervous reactions varies greatly depending entirely upon the individual.

In any event, there is no doubt that all of these patients who, following the classical theory, could be considered as suffering from vasomotor paralysis, reacted normally to the hot and cold water baths.

From these observations, one would conclude that the complete section of the lower dorsal spinal cord, the compression of this organ, the complete removal of the cervicothoracic sympathetic, the section of the lumbar rami communicantes, the section of important nerve trunks, for example, the median, radial, or sciatic nerves, or the roots of the brachial plexus, will not prevent the vessels from reacting normally to adequate excitations. They still contract under the influence of peripheral cold and dilate on the application of external heat.

We should like to emphasize this point by utilizing the example furnished by the patient who had a complete section of the sciatic nerve which had produced trophic complications. He was successfully submitted to a perifemoral sympathectomy and later to a lumbar ramisection. The last lumbar ganglion was also removed. One would conclude that this patient would have as nearly as possible a complete interruption of the vasomotor fibers. Nevertheless, his reactions to heat and cold remained normal on the side affected by the operation.

In summary we may say that:

1. After section of the so-called vasomotor nerves, the blood vessels are not paralyzed. They are still able to contract and dilate upon the external application of heat and cold.

2. The reflexes which affect the circulatory changes associated with the external temperature must be considered independent of the spinal cord and of the centers of the sympathetic trunk. The fact that these reactions remain normal, even though the section of the spinal nerves dates back far enough for degeneration of the peripheral ends to occur, proves that there can be no question of any axone reflex.

For this reason, we are once more obliged to stress the great importance of the vasomotor to the peripheral, intramural centers which we believe are contained in the arterial wall itself. It seems to us that the vascular changes following the external application of heat and cold illustrate the simplest type of vascular reflex and require only the integrity of the intramural centers. It is, however, a true reflex because it needs a sensory element capable of appreciating the variations of the temperature and a motor element which

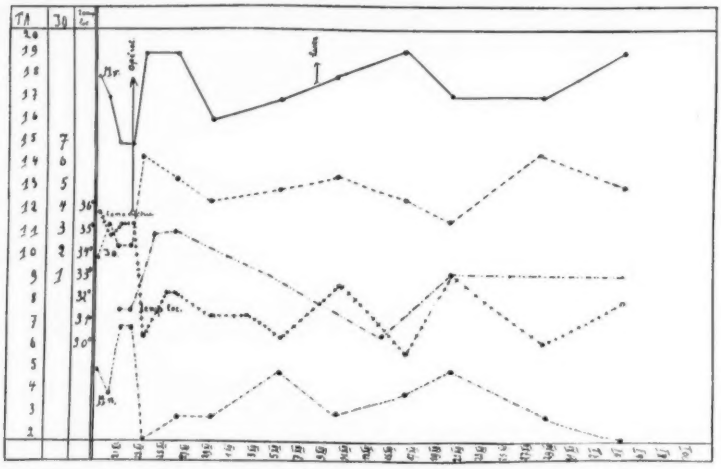

Fig. 7. Left leg (extremity operated upon). Same case as recorded in Figure 5. Figures 7 and 8 show the same variations on the lower extremities. *Mx* and *I.O.* increased immediately after operation, but *Mn* decreased. After a short period of fluctuation, caused by the fact that the patient was allowed to get up, the circulation became normal again. The difference between the postoperative augmentation of *Mn* in Figures 7 and 8 and the diminution of the same *Mn* in Figures 5 and 6 is not real. It is due to the different methods used for determining blood pressure. It is well known that the oscillometric method establishes a value that is too low for *Mn* whenever the oscillometric index increases considerably (See Leriche and Fontaine. Arch. d. mal du coeur, Jan. 1926). ——, *Mx*, indicates maximum blood pressure; –.–., *Mn*, indicates minimum blood pressure; – –, *I.O.*, indicates oscillometric index; ++, indicates tonometric index; –..–.., indicates local temperature.

controls the contraction or dilatation of the vessels.

We do not believe that all vascular reflexes have such a short path. This can be demonstrated by the study of vascular changes following the application of mustard oil, as done by Bruce, Breslauer, and Fischer. In experiments upon a cat, Breslauer and Bruce have observed that an inflammatory redness can be produced with mustard oil even after complete section of the spinal cord, if the section is not of too long standing. We have found the same to be true in humans for instance, a patient who had a spinal cord section at the level of the eighth dorsal segment gave a positive reaction in the anæsthetized region of the lower limbs 10 months after the section, but the reaction was less marked than on the intact upper extremities.

Bruce and Breslauer also observed that following section of a nerve trunk the mustard oil test remained positive as long as the peripheral nerve endings had not entirely degenerated. The reaction does not occur in the anæsthetized region years after the section.

Truncular anæsthesia does not prevent the reaction, but the local infiltration of novocain abolishes it entirely (Breslauer).

Our patient who had had a section of the sciatic nerve in 1916, had a negative mustard oil test, but on the other hand our patients who had undergone sympathectomies all showed normal reactions. So we agree with Bruce and Breslauer that the mustard oil test is based upon an axone reflex and, as such, requires at least partial integrity of the peripheral part of a sensory nerve.

This shows that all vascular reflexes do not travel the same path. The way may be simple or it may be more complicated. The reaction to heat and cold is an example of the very short reflex while the vasomotor changes produced by mustard oil enter into the group of axone reflexes. We can, therefore, divide the vascular reflexes into the following groups:

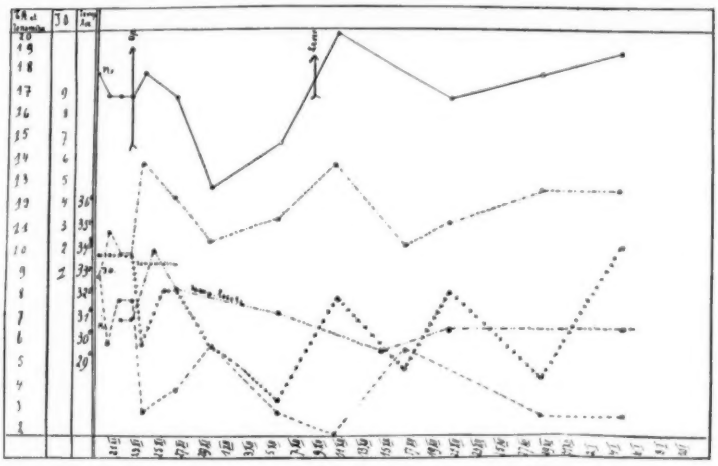

Fig. 8. Right leg. Same case as that recorded in Figure 5.

1. Peripheral vascular reflexes having their center in the intramural plexuses.
2. Vascular changes through axone reflexes.
3. Intrasympathetic reflexes which have their center in the ganglia of the sympathetic trunk.
4. Medullary vascular reflexes.
5. Cerebral vascular reflexes.

If there are long vascular reflexes, it seems to us that no doubt remains that the motor innervation of the vessels comes from intramural centers which correspond to the similar centers in the gut and the heart.

Besides these peripheral centers there is a rich extrinsic nervous system consisting of association fibers only, which makes it possible for the vascular changes in one part to be in harmony with the blood supply of the whole body. This extrinsic nervous system, which is composed of excitor and inhibitory fibers, plays a most important rôle, but it should never be thought to consist of centrifugal fibers partly vasoconstrictor and partly vasodilatator. To demonstrate its action, we cite the following observations:

In patients with an old section of the sciatic nerve we often observed that the leg suddenly became very much reddened and very warm, then later, for apparently no reason, it became very cold. We found that the local temperature was lower than that of the other limb. During both periods, normal vascular changes could be obtained with hot and cold water. We now believe that these very rapid and spontaneous changes from extreme vasodilatation to extreme vasoconstriction, which occurred for no apparent reason when the patient was in bed, indicate that after the section of the sciatic nerve, which contains the association fibers for the lower limb, these vessels lose the ability to regulate their own circulation in harmony with that of the rest of the body.

Such being the case, we must admit that every vasomotor reaction regularly produces two kinds of vascular changes: (1) changes in the local circulation of the region, affected by the operation, through short reflexes, and (2) changes in the general circulation through long reflexes.

A very simple experiment demonstrates this point. If one dips one's hand in hot water the skin becomes red in a few minutes. The color of the skin on the other side does not change but on examination with the oscillometer we find increased oscillations on both sides. So if one considers only the effect upon the blood pressure, one would say that the vascular changes are bilateral. However, if one notices only the change in color, one would say that the effect was strictly unilateral and limited to the area where heat was applied.

Fig. 9. Left side (operated upon). Normal curve. Mr. B. (Figs. 9 to 14) suffered from essential bronchial asthma and consented to extirpation of the left stellate ganglion. The operation was followed by a suppression of the vasomotor nerves of the upper extremity. Fifteen days later the hot and cold bath test was performed. After the normal curves shown in Figures 9 to 12 were registered, the two forearms were alternately submerged in cold (Figs. 10 to 13) and in hot water (Figs. 11 to 14). The curves show that the cold water diminished and the hot water increased the heights of the oscillations in the same way on the operated left as on the intact right side.

Fig. 10. Left side after cold bath.

Fig. 11. Left side after hot bath.

Actually, the immersion in hot and cold water produces two kinds of vascular changes: that is, local variations through short reflexes and general changes by long distance reflexes, only the last having a bilateral effect. By measuring the blood pressure we obtain the effect of the long reflexes only; the modifications in the local circulation are more difficult to ascertain, and we generally see their effect only in the form of increased local heat.

Under certain conditions, especially where the excitations are slight, the influence upon the general circulation may be so small as to be nearly absent, but generally speaking, the effect of peripheral excitation upon the circulation can be found. Lately, in collaborating with Dr. Milojewitch, we have observed this in peripheral traumata of the limbs which instantly produce changes in the local and general circulation.

Therefore, if one always considers in all vasomotor reactions the double effect upon the local and the general circulation, it becomes easy to understand the apparent discord which exists after sympathectomies where one finds on one side a transitory but generalized effect upon the maximum and minimum pressure, the oscillometric index and the arteriolar pressure and, on the other side, a strictly localized hyperæmia which is very persistent.

The modifications in the general pressure are the result of long distance reflexes produced by the operative trauma; the hyperæmia is the consequence of the suppression of a certain number of association fibers with pressor effect. This suppression gives the arteriole-capillary system a certain degree of autonomy, lowers the arteriole-capillary tonus, and produces a peripheral vasodilatation. However, the vessels are not paralyzed and the vasomotor phenomena produced are active and not passive.

In other words, every sympathectomy produces (1) changes in the general circulation through long reflexes which are produced by the operative trauma of the nerves of the vessels; (2) modifications in the local circulation of the limb operated upon, which are the consequence of the suppression of the association fibers with pressor effect.

Therefore, the changes which occur after sympathectomy, should be explained as follows:

1. After a periarterial sympathectomy the contraction of the arterial segment operated upon is the result of a direct trauma of the

Fig. 12. Right side (intact). Normal curve.

Fig. 13. Right side after cold bath.

Fig. 14. Right side after hot bath.

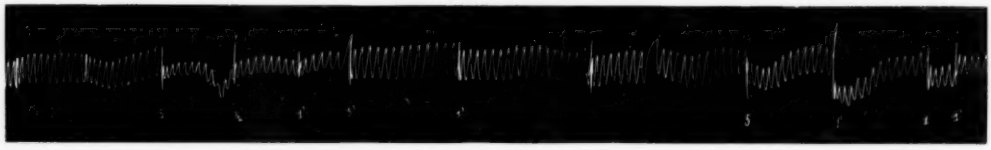

Fig. 15. Mrs. S. Section of the communicating rami of the left stellate ganglion had been performed 1¼ years before. The curve was determined under a constant pressure of 9 centimeters of mercury. The left forearm was alternately submerged in cold and hot water. The reactions were also normal in this case.

intramural peripheral centers. This contraction lasts only a few hours. The vasodilatation which follows is produced by long reflexes. For this reason it may be bilateral and even produce modifications in the maximum and minimum pressure and the oscillatory index in all four extremities.

2. The periarterial sympathectomy changes the circulation in the extremity operated upon and this simultaneously produces an increase in the local heat.

These local changes are less marked after periarterial sympathectomy than after sympathectomy upon the trunk, the reason being that a periarterial sympathectomy does not interrupt so many pressor fibers. The hyperæmia is, therefore, less marked and less persistent than after operations upon the sympathetic trunk.

3. After operations upon the sympathetic trunk the same vascular changes occur as those after periarterial sympathectomy, but since the arterial wall is not directly injured the initial contraction does not occur.

CONCLUSIONS

1. The motor innervation of the vessels is due to peripheral nerve plexuses in the arterial wall itself.

2. The extrinsic nerves of the vessels play the rôle of association fibers with pressor or depressor effect.

3. The simplest vascular reflex has the peripheral plexuses as a center and the reaction to heat and cold is a reflex of this kind.

4. There are more complicated vascular reflexes: (a) the axone reflex (as demonstrated by the mustard oil test), (b) intrasympathetic), (c) spinal cord and (d) cerebral vasomotor reflexes.

5. Every vasomotor reaction should be considered from two standpoints, namely: its influence upon (a) the general circulation and (b) the local circulation of the limb operated upon.

6. In the particular case of sympathectomy this double effect must be taken into consideration. The modifications in the blood pressure are common to all four extremities

and therefore symmetrical. They are transitory and due to long distance reflexes produced by the operative trauma of the vascular nerves. The local changes are more persistent, but strictly confined to the side operated upon. They may be explained by the suppression of certain fibers with pressor effect.

7. The vascular changes are the same after both periarterial sympathectomy and operation upon the sympathetic trunk, but, in the latter case, the modifications in the local circulation are more marked as more pressor fibers have been cut. There is a quantitative but not a qualitative difference between these two operations.

8. Our theory of the vasomotor activity is not contradicted by anatomical factors. Even if the segmentary innervation of the vessels be true one can understand that a periarterial sympathectomy, although it may be made at a level far distant from the lesion, may through long reflexes produce general changes in the circulation and lower the arteriole-capillary tonus by the suppression of some pressor fibers, thus producing an increased local heat[1]. The fact that the hyperæmia after periarterial sympathectomy is less persistent than after sympathectomy upon the trunk, only demonstrates that with the latter more pressor fibers are cut[2].

Such are our observations and conclusions on sympathectomies performed upon humans. Our theory has not yet the anatomical confirmation that intramural centers do exist in the arterial wall, for to date, they have been found in only a few vessels. We hope that we shall some day be able to prove their existence.

BIBLIOGRAPHY

1. Belinky. Zur Frage nach d. Physiolog. Effekt der Peri-art. Symp. Centr.-org. f. Chir., 1927, xxxvii, 261.
2. Breslauer. Die Pathogenese der trophischen Gewebsschaeden nach Nervenverletzung. Deutsche Ztschr. f. Chir., 1919, cl, 50.
3. Brown, G. Physiologic studies on the vasomotor changes after lumbar symp. ganglionectomy and perivascular neurectomy. Ann. Clin. Med., 1926, v, 2.
4. Idem. The treatment of peripheral vascular disturbances of the extremities. J. Am. M. Ass., 1926, lxxxvii, 379–383.
5. Brown, G., and Adson, A. Calorimetric studies of the extremities following lumbar symp. ramisection and ganglionectomy. Am. J. M. Sc., 1925, clx, 232.
6. Brown, G., and Rowntree, L. Vasodilatation following symp. neurectomy. Am. Heart J., 1925, i, 2.
7. Bruce. Ueber Beziehung der sens. nervenendigungen zum Entzuendungsvorgange. Arch. f. exper. Path. u. Pharmakol., 1910, lxiii, 424.
8. Bruening. Ueber die Gefaessinnervation an den Extremitaeten. Klin. Wchnschr., iii, 2087–2090.
9. Bruening, F., and Stahl, O. Die Chirurgie des Veget. Nervensystemes. Berlin: Springer, 1924.
10. Dumpert, V., and Flick, K. Ueber den Verlauf d. sens. Gefaessnerven in den Extremitaeten. Deutsche Ztschr. f. Chir., 1925, cxc, 329–333.
11. Foerster, O. Die Schmerzempfindung u. die chirurgische Behandlung der Schmerz-zustaende. Sonderband z. Beitr. z. klin. Chir., 1926.
12. Fontaine, R., and Milovewitch, D. Contribution à l'étude expérimentale des troubles vasomoteurs post-traumatiques des membres. Rev. de chir., 1927, 385–395.
13. Friedrich. Klin. Wchnschr., 1924, xxxviii, 1741.
14. Hahn. Erfahrungen mit d. Symp. Klin. Wchnschr., 1924, 42.
15. Hahn and Hunczek. Anat. Untersuchungen ueber d. Nervenversorg. d. Extremitaetengefaesse. Beitr. z. klin. Chir., 1925, cxxxiii, 302.
16. Hellwig. Arch. f. klin. Chir., 1924, cxxviii, 282.
17. Hirsch. Schmerzbahnen d. Extremitaetengefaesse. Klin. Wchnschr., v, 651.
18. Idem. Ueber Nervenversorgung d. Gefaesse im Hinblick auf das Problem d. peri-art. Sympathektomie. Arch. f. klin. Chir., 1925, cxxxvii, 281–9.
19. Hoar, J. Studies of the nervous control over the blood flow and metabolism in the peripheric tissues, which are warmed or chilled by the application of external heat or cold. Arch. f. jap. Chir., 1926, iii, 1.
20. Kramer and Todd. The distribution of nerves to the arteries of the arm. Anat. Record, 1914, viii, 243.
21. Leriche, R. De l'élongation et de la section des nerfs péri-vasculaires dans certains syndromes douloureux et dans quelques troubles trophiques. Lyon chirurg., 1913, 378.
22. Idem. Des points litigieux de la question de la sympathectomie péri-artérielle. Arch. franco-belges de chir., 1924, xxvii, 10.
23. Idem. Indications et resultats de la sympathectomie péri-artérielle dans la chirurgie des membres. Cong. franç. de chir., 1927, xxxvi
24. Leriche, R., and Fontaine, R. Faits chirurgicaux pour servir a la critique des théories actuelles de la vasomotricité. Presse méd., 1927, xxxi, 16.
25. Idem. Experimental researches upon vasomotricity. Ann. Surg., 1927, lxxxv, 641–646.
26. Idem. Recherches expérimentales sur l'innervation vasomotive. Les réflexes vascularises des membres. Presse méd., 1927, xxxv, 852–854.
27. Ljetnick. Die Verteilung d. Nervengefaesse in der Adventitia der Gefaesse. Anat. Anz., 1925, lix, 467.

[1] The existence of long fibers in the arterial sheaths of the vessels is not indispensable to our theory of vasomotor activity. Nevertheless, we believe that in some cases there must be sensory conduction along the blood vessels. We cannot explain in any other way why we have seen the femoral artery remain painful after a correctly performed spinal anæsthesia. The conservation of deep sensation after complete paralysis of the cerebrospinal nerves as seen in certain cases by Thomas and Foerster and ourselves, would indicate this. If long fibers do not exist in such cases, we must conclude that the sensations are carried along the vessels in the intramural plexuses themselves to the place where the vessel encountered either an intact spinal nerve or received a direct fiber from the sympathetic trunk.

[2] Our theory also explains how a unilateral sympathectomy may have a bilateral therapeutic effect which in such cases is due to the modifications in the general blood pressure produced by the operation. But as in the limb operated upon we also have an increase in the local blood supply of the tissues, the vascular changes will always be greater there than elsewhere.

28. Magnus. Experiments in innervation of vessels. Arch. f. klin. Chir., 1926, cxliii, 574.
29. Odermatt. Die Schmerzempfindung d. Blutgefaesse u. die Gefaessreflexe. Beitr. z. klin. Chir., 1922, cxxvii, 1684.
30. Pagano. Arch. ital. de biol., 1900, xxxiii, 1.
31. Potts. The distribution of nerves to the arteries of the leg. Anat. Anz., 1925, xlvii, 138.
32. Schilf and Stahl. Physiol. Unters. ueber die periph. Bahnen d. Gefaessinnerv. Klin. Wchnschr., 1925, iv, 1390.
33. Stahl, O. Beobachtungen an Gefaessen nach Operationen am Sympathicus. Archiv. f. d. ges. Physiol., 1924, cciii, 57–60.
34. Stewart and Laffer. Arch. internat. Med., 1913, ii, 365.
35. Thomas, A. Compt. rend. Soc. de biol., 1917, lxxx, 872.
36. Von Tschermack. Die Lehre von der tonischen Innervation. Wien. klin. Wchnschr., 1914, xxvii, 309–314.
37. Wiedhopff. Experim. Untersuch. ueber die Wirkung d. P. S. A. u. die Nervenvereisung an den Gefaessen der Extremitaeten. Beitr. z. klin. Chir., 1924, cxxx, 399–445.
38. Idem. Der Verlauf der Gefaessinnervation in den Extremitaeten u. deren Wirkung b. der Peri-art. Symp. Muenchen. med. Wchnschr., 1925, lxxii, 413–417.

LEIOMYOMATA OF THE INTESTINES[1, 2]

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SMOOTH muscle tumors of the intestines occur frequently enough to be considered in the differential diagnosis of intra-abdominal tumors and in establishing a possible causative factor for certain intestinal complaints including intestinal obstruction. The frequency of a mistaken diagnosis warrants reporting a case in detail and calling attention to the clinical and pathological aspect of this type of neoplasm.

CASE REPORT

Mr. L. S., Polish, 44 years old, was admitted to Wesley Memorial Hospital on June 6, 1927. His wife and 5 children were living and well. His only complaint was of a large, painful mass in the upper right abdomen which he had first noticed about 6 months previously. Pain had first been felt in this region about 10 months previously. At that time it was neither severe nor constant, but it gradually grew worse and became practically constant. There was no food relation to the pain and the patient had been able to eat anything. His appetite had remained good until shortly before coming to the clinic. There was no nausea or vomiting. He had no dyspnœa, no cough or chest pains, and no frequency of urination, and there was no association of the pain with urination. He had had occasional headaches but no vertigo. He slept well. During the past 2 months before entering the clinic he had had 3 or 4 watery stools daily. He had lost 35 pounds in weight during the past 10 months. His past and family history gave no additional information and he denied any venereal infection.

An examination revealed a rather poorly nourished male with pale skin and thin gray hair. There was no discharge from the ears. The pupils reacted to light and accommodation. The tongue was furred and the teeth were in poor condition. The supraclavicular fossæ were sunken and the chest was thin, but the lungs were essentially normal as to physical findings. The heart was normal. The skin of the abdominal wall was atrophic and the muscles were relaxed. An ovoid mass could be palpated in the right side. It extended from the costal margin down to the crest of the ilium and from the median line well to the right flank. It was smooth, firm, freely movable, and not especially tender. When the patient lay on his left side the tumor would shift well to the left side of the abdomen; it descended with inspiration and seemed to swing from the gall-bladder site. The lower edge of the liver could be palpated on deep inspiration and lay anterior to the tumor. The spleen was not palpable but it was thought that the right kidney could be felt behind the mass. The prostate felt normal in size. All reflexes were normal. In the left buttock was found a soft, well-defined mass about the size of a lemon. This was freely movable and thought to be a lipoma.

The stools were semi-solid, brown, and well digested. The benzidine test for blood was strongly positive and there was present an occasional pus cell but no mucus. The blood Wassermann was negative. The urine had a specific gravity of 1030, was amber in color and turbid, with a faint trace of albumin and no casts. There were 75 white cells per 1/8 field. At other times double-plus albumin with hyaline and granular casts was found. The blood count showed hæmoglobin 70 per cent, red blood cells 4,760,000, leucocytes 11,300, polymorphonuclears 86 per cent, lymphocytes 12 per cent, large mononuclears 2 per cent. A cystoscopic examination showed a normal bladder mucosa with slight enlargement of the median lobe of the prostate. The ureteral orifices were normal and clear urine could be seen spurting from each. The ureteral catheters passed easily, phthalein appearing from the left

[1] Read before the Chicago Surgical Society, May 4, 1928.
[2] From the Department of Surgery, Northwestern University Medical School and Third Surgical Service, Wesley Memorial Hospital, Chicago.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1. Pyelogram of the right kidney showing a fairly normal pelvis and calices with the kidney in a normal position. The ureter is shown pushed well to the left.

Fig. 2. Roentgenogram of the stomach and duodenum showing the organs pushed to the left.

Fig. 3. Roentgenogram of the colon. The ascending and hepatic flexures of the colon are pushed down and to the left. Again the right upper abdomen is empty.

side in 2 minutes and from the right side in 4 minutes. Differential secretion: right side, 44 cubic centimeters with 15 per cent phthalein; left side, 48 cubic centimeters with 13.5 per cent phthalein. Pyelography showed the right ureter bowed to the left, the pelvis and calyces filled rather atypically, but the kidney was in a normal position (Fig. 1). The left side appeared normal. A gastro-intestinal X-ray with barium revealed nothing abnormal except that the stomach was displaced to the left, the pyloric end seemed shortened, and the villous duodenum less close to the median line than normal (Fig. 2). There appeared to be no bowel in the right upper abdomen and the ascending colon and the hepatic flexure seemed to be pushed to the left and downward (Fig. 3). *Summary.* No intrinsic pathology was found in the gastro-intestinal tract. The mass on the right side was not part of the stomach, duodenum, or head of the pancreas. High grade arteriosclerosis of the pelvic vessels and high grade hypertrophic osteo-arthritis of the lumbar bones and joints were present. A gall-bladder visualization failed to show a shadow.

Examination of the kidney, stomach, and pancreas was negative. Since a gall-bladder shadow was not produced with the intravenous administration of the dye and since the mass seemed to swing from the gall-bladder site, a diagnosis of tumor of the gall

Fig. 4. The tumor with attached ascending colon and cæcum. This photograph shows the knob lying close to the colon, also the veins which were situated in the capsule of the tumor.

Fig. 5. The tumor as it appeared on section showing its attachment to the bowel. The dark areas are due to old hæmorrhage with degeneration. Two small tumors can be seen lying between the main tumor and the gut wall.

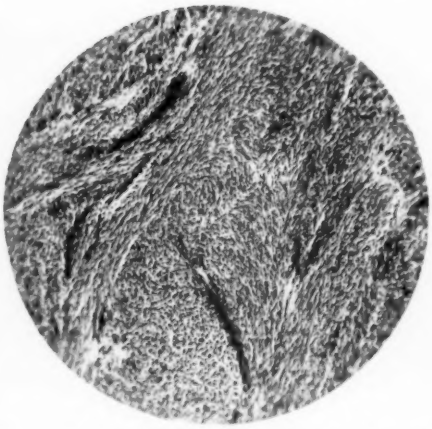

Fig. 6. A low power photomicrograph showing typical smooth muscle cells.

bladder was made, although we questioned the possibility of a gall-bladder shadow if the viscus overlay the tumor due to the opacity of the tumor.

Operation. On July 7, the abdomen was opened through a right paramedian incision. When the peritoneal cavity was opened a large tumor mass came into view. This mass lay behind the ascending colon and pushed the hepatic flexure to the left and downward. The lower edge of the right lobe of the liver projected over the upper part of the tumor. The gall bladder was free and moderately filled with bile and lay over the tumor. The tumor mass felt

Fig. 8. A moderately high power photomicrograph showing a blood vessel with practically no wall. The surrounding cells are of smooth muscle.

Fig. 7. A high power photomicrograph showing the typical cigar shaped nuclei of smooth muscle cells.

smooth except for a knob which could be seen projecting from the median lower surface of the tumor to the left of the ascending colon. The parietal peritoneum, which was reflected from the external surface of the ascending colon, was split and the mass rather easily enucleated from behind the colon. An area of the anterior surface of the tumor about 8 centimeters long and 2 centimeters wide was closely adherent to the posterior surface of the colon. It

Fig. 9. A low power photomicrograph of a section cut through the area of attachment of the tumor to the gut wall. Although the tumor mass at the lower part of the photograph does not appear to be growing directly from the gut musculature, it is nevertheless very closely associated with it.

Fig. 10. A schematic drawing illustrating how the tumor, when it grows from the longitudinal layer of gut musculature, extends outward and forms an external type of tumor.

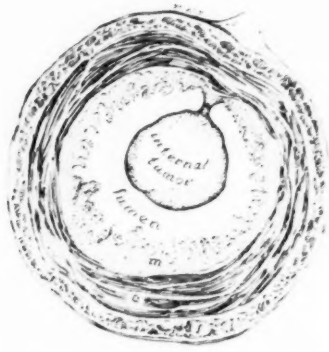

Fig. 12. Schematic drawing illustrating how the tumor, when it grows from the muscularis mucosa, extends into the lumen of the gut and becomes a pedunculated internal myoma.

seemed unwise to try to separate this for fear of opening the bowel lumen as the mass no doubt grew from this site and derived most of its blood supply through the attachment. The ascending colon and cæcum were resected and the terminal ileum was anastomosed to the hepatic flexure by lateral anastomosis. The abdomen was closed in three layers. The patient withstood the operation very well and left the table with a pulse of 84. Convalescence was uneventful. The stitches were removed on the eighth day. On the morning of the ninth postoperative day the patient said he felt well. Temperature was 99 and pulse 74. When the dressing was examined, however, two loops of bowel were found protruding through the wound. The patient was immediately taken to the operating room. The abdomen was cleansed, the loops of bowel were irrigated with salt solution, and the periphery of the wound was blocked with novocaine solution. It was found that the entire fascial suture line had given way, as well as half of the skin and peritoneal suture. The gut was replaced and the wound resutured, and a cigarette drain was left extending into the peritoneal cavity. The sutures were left in for 21 days. Convalescence was smooth and the patient left the hospital on August 22, feeling perfectly well and with the wound completely healed.

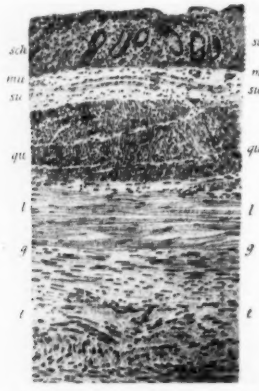

Fig. 11. Photomicrograph of a longitudinal section of the gut wall showing the transition of normal muscle into tumor (Taken from Steiner). Sch, The slightly thinned and somewhat infiltrated mucosa; mu, atrophic muscularis mucosa; su, submucosa which is thinned and slightly infiltrated; qu, slightly thinned but not infiltrated circular muscular layer; l, longitudinal muscle layer; g, zone of transition into tumor; t, the tumor in which the muscle cells are larger and more abundant than in the normal muscle layer. The nuclei are larger.

THE TUMOR

The tumor weighed approximately 1050 grams. It measured 13 centimeters in its widest diameter and was ovoid in contour. One knob about 3 centimeters in diameter and 2 centimeters in height projected from what had been the anterior inferior surface (Fig. 4). The surface of the tumor was smooth with here and there tags of connective tissue. Many fair sized veins lay in the capsule. The color varied from grayish-white to pink-white with areas of brownish discoloration. The mass was of a firm consistency and offered considerable resistance to cutting. The cut surface varied in color from gray to pinkish-white. Areas measuring as much as 3 centimeters in diameter were brown in color and represented old hæmorrhage with degeneration (Fig. 5).

Many whorls of neoplastic growth as in uterine myomata could be seen. Lying between the main tumor mass and the resected gut were two small nodes, one about 3 by 2 centimeters and another somewhat smaller. The cut section of these nodes was very pale. The entire mass was intimately attached to the gut wall over an area about 5 centimeters in length and 2 centimeters in breadth.

Sections from the tumor showed typical smooth muscle cells with characteristic cigar shaped nuclei (Figs. 6, 7). The same type of cells was found in the several small nodes already described. In selected areas the body of the muscle cells seemed atrophic but as a rule the nuclei retained their morphological characteristics. In some areas thin walled blood vessels were few while in other regions they were quite numerous (Fig. 8). Sections through the areas of discoloration indicated degeneration of the muscle fibers. There was present in the white, firm areas a large amount of connective tissues with hyalinization. Œdema was present in various parts of the tumor. A large section cut through the area of attachment of the tumor to the gut wall failed to indicate definitely that the tumor took its origin from the musculature of the gut wall, although there was a close association between them (Fig. 9).

This was, therefore, a leiomyoma growing from the ascending colon.

Throughout the literature, occasional references are found to myomata of the gastro-intestinal tract. In 1898 Steiner gave a detailed description of this tumor, and reported from the literature 58 cases of myoma of the gastro-intestinal tract, 23 growing from the stomach and 35 from the gut, including 3 new cases. The earliest reference was made by Boerhave in 1728, who mentioned "Polypoeses Gewaeches der Fleischschichte des Darmes." Probably the first authentic description was by Foerster in 1858, who described the "Fibroid of the Muscularis of the Ileum."

PATHOGENESIS

Needless to say no definite etiological factor can be vouched for. Steiner mentioned the frequency of small circumscribed myomata or polyps near areas of diffuse hypertrophy of the stomach and gut musculature, the tumors being the result of irritation. This followed the theory of Virchow. Winkle went one step further and stated that he believed the tumor to be the result of disturbance in circulation due to trauma or inflammation with possible changes in the vessel walls due to syphilis or chemical changes in the blood such as caused by parasites. Gottschalk found among the muscle cells in very small myomata, chromatin-rich nuclei. He believed these to be nuclei of muscle cells or nuclei of cells of the lymph vessels or mast cells and attributed great importance to them. Since they are not found in larger tumors, he believed that they must play a decisive rôle in the etiology of the tumor.

The immediate site of origin of the tumor must be in a muscle structure of the gut wall, either of the muscle coats or the muscularis mucosa (Foerster, Virchow, Boettcher, Brodowski, Wesener). Klebs and Roesger believed that the tumor grew from the muscle of the vessel walls. Lubarsch also concurred in this as he had seen small myomata intimately associated with blood vessels.

According to Virchow, the tumor begins its growth in a muscle stratum, just as a neuroma grows in a nerve. As it increases in size it pushes adjacent tissues aside and extends either inward into the lumen of the gut or outward into the peritoneal cavity or extraperitoneal space. When the growth finds its origin in the longitudinal muscle it becomes an external growth, but when it grows from the circular layer it becomes an internal growth.

If one may reason logically it would appear that a small tumor, which had its origin in the longitudinal muscle, as a result of the resistance of the constantly contracting circular muscle, would progress externally (Figs. 10, 11); but that when its seat of origin is in the circular layer, its growth most likely would be toward the lumen and would be sessile in type. When the origin is in the muscularis mucosa as a result of the constant traction of intestinal peristalsis a typical pedunculated internal tumor would develop (Fig. 12).

The malignant changes in myomata, especially in those cases in which metastasis occurs, have constituted a topic of contro-

versy. Zeit believes that true malignant changes may take place but that benign metastases do occur in the form of emboli of tumor cells which may be carried to the liver. Here they are ordinarily destroyed but the cells may remain viable or may even grow and produce secondary but benign growths. Ghon and Hintz reported a case in which the primary tumor was in the ileum and caused intussusception. There were secondary nodules in the abdominal wall, lungs, chest wall, pancreas, both suprarenals, in the capsule of both kidneys, mucosa of the stomach, 50 in the small intestines, and a thrombus of tumor cells in the seventh intercostal vein. The colon, prostate, and large lymph-gland groups were free. A number of other cases have been reported. There seems to be no question but that smooth muscle cells may take on an atypical growth, the resultant tumor being sarcomatous in nature, and that metastases can and do take place (Langerhans, Hanseman, Minkowski).

Since leiomyomata find their classical prototype in uterine myomata, the latter having been studied in large groups, little can be added to the pathological picture of the tumor itself. Nevertheless in intestinal myomata the clinical picture lends itself to a classification which is of both pathological and clinical importance, viz., the external type which appears as an abdominal tumor and gives symptoms of being an abdominal tumor, the internal type which produces a variety of irritative intestinal symptoms often culminating in obstruction, and the rectal type which, due to its location and characteristics, is usually mistaken for a carcinoma.

EXTERNAL MYOMA

It is assumed that the external myoma finds its origin in the longitudinal layer of the gut musculature. The growth is outward and the leaves of the mesentery are spread or the visceral peritoneum is pushed away. The growth is at the expense of the extra-intestinal tissues. These tumors are rarely if ever pedunculated and have a fair sized base through which most of their blood supply is derived. According to the age and rapidity of growth of the tumor, the size may vary from that of a cherry to that of a mass filling the entire abdomen. In Woelfler's case the tumor weighed 7 kilograms. It seems that the larger the attachment of the tumor to the gut wall the more likely is rapid and progressive growth. Adhesions are not uncommon, but never to the extent that the tumor becomes fixed. As a rule the mass is freely movable until it reaches the size where, due to bony or solid visceral proximity, mobility is prevented. The mixed variety may encroach upon the lumen of the bowel and produce partial or complete obstruction. Adjacent organs are often compromised and pressure atrophy of the liver and pancreas may result.

The outstanding sign is the presence of a tumor which has rather free mobility, is frequently nodular, and not especially tender. The growth is comparatively slow, at times extending over a period of many years. For example, Kukula reported a case in a male, 71 years of age, in whom the growth had been felt for 20 years, first as a nodule the size of a hazel nut, later the size of a fist, and finally as large as a child's head. When the growth takes place in the wall of the small gut, disturbances in intestinal flow are more common than when the tumor is situated in the colon. This is due to the formation of traction diverticula and adhesions with angulation or pressure. When partial obstruction occurs, cramps, vomiting, and obstipation are common and intermittent, as a rule. Rarely is the obstruction complete. Strangulation or incarceration of the tumor is possible as in Kukula's case in which part of the tumor was incarcerated in a hernial sac. Sooner or later, due to changes in the mucosa, inflammatory or ulcerative in nature, bloody or mucous diarrhœa may alternate with constipation. In my case, in spite of a large tumor, there were no obstructive symptoms at any time, but for several months before the patient reported at the clinic, he had had from 3 to 4 watery stools each day and an examination of the fæces in the clinic revealed the presence of blood and pus cells. Steiner reported a case of fatal hæmorrhage.

The outstanding diagnostic points can be briefly summarized as follows: an intra-abdominal, slowly growing, often nodular, freely

movable, not especially tender tumor, which is not connected with the genital tract, the manipulation of which produces a drawing pain, and which eventually causes disturbances in the passage of intestinal contents and hæmorrhage. To this can be added the evidence obtained by means of the X-ray with contrast media in the gastro-intestinal, urinary, and biliary tracts.

INTERNAL MYOMA

An internal myoma most likely grows from the muscularis mucosa but rarely attains the size of the external variety because of the early encroachment upon the lumen of the gut and resultant intestinal obstruction. It is most frequently pedunculated and the pedicle often attains a considerable length. The mucosa over the tumor may remain intact, especially when the tumor is still small. Eventually erosions and ulcerations result. Inflammation of the surrounding mucosa follows and accounts for the symptoms frequently observed. In cases of deep ulceration, rather brisk hæmorrhages may occur. The pedicle may atrophy and eventually cut through, thus isolating the tumor in the intestinal lumen. The tumor may then be spontaneously passed *per rectum*. In Pellizari's case, a girl presented a fair sized tumor in the ileocæcal region, which was thought to be an ovarian cyst. She began having severe abdominal cramps, vomiting, obstipation, and fever. Finally symptoms of ileus appeared. Suddenly the patient passed the tumor, which weighed 500 grams *per rectum*. Prompt recovery ensued.

It is possible for a small tumor to be present for a long period of time without producing any symptoms, but with increase in size or ulceration, symptoms make their appearance. Diarrhœa alternating with constipation, mucus in the stools, bleeding of all degrees from occult blood to exsanguinating hæmorrhage may occur. With partial obstruction there follow cramps, vomiting, obstipation with varying degrees of distention. Often these symptoms very suddenly disappear and, coincident with the relief, the patient passes large quantities of foul, bloody, mucous stools. Not a few of these patients sooner or later develop an intussusception with its classical picture, but varied by frequent, sudden, and spontaneous relief and then recurrence. In the presence of a fair sized tumor or an intussusception a mass may be felt in the abdomen. This mass has a tendency to vary in size, the decrease being synchronous with symptomatic relief. Obstructive symptoms may occur over a long period of time as in Heurteaux's case, in which the patient suffered attacks for over 10 years and then the lime covered tumor appeared in the rectum.

Steiner tabulated the symptoms as follows: (1) the frequent sudden appearance of a tumor in the lower abdomen, (2) a tumor in the abdomen which grows slowly for months or years, (3) the sudden increase or decrease in the size of the tumor, signifying regression or progression of the invagination, (4) with the increase in the size of the tumor, the appearance of intestinal stasis, (5) coincident with the decrease in size of the tumor, disappearance of the symptoms with the passage of foul fæces, (6) complete relief of symptoms after a severe attack of intestinal obstruction, the freedom lasting weeks, months, or even years.

These diagnostic points are as reliable and complete today as they were 30 years ago and little can be added except perhaps the evidence obtained by the newer laboratory methods such as gastro-intestinal X-ray with contrast media, pyelography, or cholecystography.

RECTAL MYOMA

Rectal myomata may be either internal or external. The internal type is usually in the form of rectal polyps. While the polyp is small it may cause few if any symptoms, but as it increases in size, constipation may alternate with blood-stained, loose stools. With ulceration, mucus, blood, and pus may be present in the fæces. The patient often complains of the sense of a foreign body in the rectum and straining at stool may extrude the pedunculated mass through the sphincter. As the tumor increases in size, more obstructive symptoms appear, leading to subtotal or complete obstruction. Coincident with the varying degrees of obstruction, colic, nausea, and vomiting occur. Digital or instrumental

examination will reveal the presence and character of the tumor.

The external type presents a perplexing and confusing picture. These tumors usually grow from the posterior wall of the rectum and after a time fill the hollow of the sacrum. The progress of growth in this direction is then arrested but the growth then proceeds upward, and laterally and pushes the rectum anteriorly toward the bladder. The mucosa is stretched over the mass, offering resistance to the onflow of fæcal contents. Ulceration and necrosis may then take place and result in mucous and bloody stools. Constipation alternates with foul, bloody diarrhœa. These tumors may attain an enormous size. Senn reported a case in a female, 45 years of age, whose peritoneal cavity was filled with fluid. After the fluid had been aspirated a large solid tumor, not attached to the uterus, was felt in the left lower abdomen. At laparotomy, a myoma weighing 12 pounds was removed. It lay behind the peritoneum and took its origin from the posterior rectal wall.

In the well advanced cases, obstructive symptoms with bleeding and foul stools are the outstanding symptoms. These patients often develop a marasmus or cachexia not unlike that due to malignancy and with the finding of a large, ulcerating fixed mass, a diagnosis of inoperable carcinoma or sarcoma is made. The long history should suggest the presence of a myoma and a microscopic examination should establish the diagnosis.

TREATMENT

Since leiomyomata are benign tumors, a thorough local removal should lead to a cure. In the external type, due to the rather broad base, it may be necessary to resect the portion of the gut from which the tumor takes its origin. In my case it was comparatively easy to enucleate the tumor but it seemed unwise to resect only the area of attachment for fear of stenosis of the gut. When the tumor is not large or when the base is small, it is quite possible to resect the attachment and close the defect in the gut wall by suture. The internal variety must be treated according to the location and the nature of the complicating pathology. Since practically every tumor has a pedicle the bowel may be incised and the pedicle removed by a wedge shaped excision, even ligation with cautery may be sufficient. In the presence of intussusception, the type of operation will depend upon the viability of the gut and the condition of the patient.

Rectal myomata offer the most technical difficulties. Small pedunculated polyps can be removed with a snare and the stumps cauterized. The large external type are exceedingly difficult to remove. Several approaches are available, viz., the abdominal route when the tumor is very large and lies high with the base of the tumor accessible from within the abdomen. When the tumor is very large and fills the pelvis, it may be next to impossible to gain entrance to the pelvis and enucleation may lead to profuse bleeding, which further complicates the operation. Berg used a modified Kraske technique with success. The method employed by Senn has much to be recommended. He ligated the rather broad pedicle in three parts and removed the tumor, then excised the base and sutured the defect in the gut wall. The patient recovered.

CONCLUSION

In conclusion, I wish to reiterate and emphasize that smooth muscle tumors of the intestines, although not common, do occur frequently enough to be considered in the differential diagnosis of abdominal tumors and intestinal obstruction, especially intussusception when the attacks tend to be spontaneously relieved only to recur again from time to time. Moreover they must be considered in the differential diagnosis of large, fixed, ulcerating and obstructing growths of the rectum.

BIBLIOGRAPHY

1. Berg. Ein Fall von Myoma recti. Rapport des Kgl. Seraphinerlazarets zu Stockholm. 1890, p. 51.
2. Boerhave. Praxis Medica. Patavia. 1728, i, 242.
3. Boettcher. Einige Bemerkungen ueber Darmmyome. Arch. f. path. Anat., 1886, civ, 1.
4. Brodowski. Ein ungeheueres Myosarkom des Magens nebst sekundaeren Myosarkomen der Leber. Arch. f. path. Anat., 1876, lxvii, 227.
5. Foerster. Fibroid der Muscularis des Ileum. Arch. f. path. Anat., 1858, xiii, 270.
6. Ghon and Hintz. Ueber maligne Leiomyome des Intestinaltraktes. Beitr. z. path. Anat., 1909, xlv, 89–109.

7. GOTTSCHALK. Ueber die Histogenese und Aetiologie der Uterusmyome. Ztschr. f. Geburtsh. u. Gynaek., 1893, xxvii, 168–176.
8. HANSEMAN. Ueber einige seltene Geswuelste des Magens. Verhandl. d. Gesellsch. deutsch. Naturf. u. Aerzte, 1896 ii, 2–8.
9. HEURTEAUX. Myome du rectum. Bull. Soc. anat. de Nantes, Nov., 1887.
10. KLEBS. Handb d. path. Anat., 1876, 886.
11. KUKULA. Retrograde Incarceration durch einen gestielten Tumor des Duenndarms. Wien. klin. Rundschau, 1895, xx.
12. LANGERHANS. Demonstration eines Praeparates von Myoma laevicellulare malignum. Berl. klin. Wchnschr., 1893, 338.
13. LUBARSCH. Hyperplasie und Geswuelste. Ergebn. d. allg. path. Morph. u. Physiol., 1895, ii, 330; 1897, 570.
14. MINKOWSKI. Praeparate von Myommetastasen in Lungen, Leber, und Muskeln. Muenchen. med. Wchnschr., 1901, xlviii, 1335.
15. PELLIZZARI. Myoma of the intestine. Abstracted in Zentralbl. f. Chir., 1875, 223.
16. ROESGER. Ueber Bau und Entstehung des Myoma uteri. Ztschr. f. Geburtsh. u. Gynaek., 1890, xviii, 131–144.
17. SENN. Intraperinoneal myofibroma of the rectum, weighing 12 pounds, successfully removed by laparotomy. Weekly M. Rev., 1891, xxiii.
18. STEINER. Ueber Myome des Magen-Darmkanals. Beitr. z. klin. Chir., 1898, xxii, 1–112; 407–440.
19. VIRCHOW. Die Krankhaften Geschwuelste. 1864, iii, 107; 128.
20. WESENER. Ueber ein teleangiektatische Myom des Duodenum von ungewoehnlicher Groesse. Arch. f. path. Anat., 1883, lxviii, 377.
21. WINKLE. Ueber Myome des Uterus in aetiologischer, symptomatischer, und therapeutischer Beziehung. Samml. klin. Vortr., 1876, xcviii, 735–764.
22. WOELFLER. Case reported by Steiner.
23. ZEIT. Personal communication.

TUBERCULOSIS OF THE EPIDIDYMIS[1]

A Critical Review Based on the Study of Ninety-Four Cases

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THIS paper is based upon a careful review of 94 cases that have been under the author's personal observation. Special attention or special analysis was given to the end-results obtained, as far as this was possible. Large series of cases dealing with ultimate end-results are rare and among papers including a large series of cases may be mentioned those of Barney, Keyes, Schoonover, Barbilian, and Soderlund.

No attempt has been made to review the literature exhaustively or to discuss in detail the different forms of treatment recommended by the various authors, but rather to present data available in a series of cases under personal supervision.

There seems to be a general tendency at the present time to study end-results obtained in various surgical diseases. Heretofore, papers dealing with end-results have been very few and far between. The papers for a long time dealt chiefly with the problems of diagnosis and differential diagnosis, as well as with surgical technique. It is needless to discuss the various factors which have stimulated the medical profession as a whole and the doctor as an individual to survey his accomplishments in order that one might determine exactly just what has been accomplished by one or another form of treatment. Often, it is true, various types of lesions occur so infrequently that one is not in a position to command a survey of a large number of cases. In these circumstances the criticism that a study of a small group does not suffice, is more or less justifiable, but, if a sufficient number of papers are reported, even though the number of cases studied which deal with end-results is small, the data which accumulate cannot be other than worth while.

Tuberculosis of the epididymis represents a type of lesion which occurs so infrequently that papers dealing with a sufficient number of end-results have been exceedingly few and far between.

AGE

The general belief that tuberculosis of the epididymis is a disease that occurs in early adult life is verified by the data in the present series of cases. There were 4 patients in this series under 20 years of age. The youngest patient was 17 years old and the oldest was 65 years old. In each decade between these two extremes, cases were recorded. The largest number of cases that occurred in any one decade was 37 in the third decade, or 39.3 per cent of the total number of 94 cases (Table I).

TABLE I.—AGE OF PATIENTS

Age in years	Cases
Under 20	4
20 to 29	28
30 to 39	37
40 to 49	9
50 to 59	11
60 to 69	3
Not stated	2
Total	94

Barney has had an unusually interesting experience with this disease in children. He recently reported a series of 11 cases in children between 9 months and 14 years of age. Barbilian in his series of 145 cases reported 19 patients between the ages of 15 and 20 years.

TRAUMA

The question as to whether or not trauma is a factor in the development of tuberculosis of the epididymis has been under discussion for a long time. Some years ago the question was of purely academic interest, but today it has a new interest, namely, an economic one, because of the Workmen's Compensation Acts and the problem of fixing liability. Not uncommonly patients state that their trouble followed an injury sustained during their employment and the cases are brought before an industrial board. The relationship between tuberculosis of the epididymis and trauma sustained during work is therefore a most important one.

[1] Read by title at the annual meeting of The Western Surgical Association held at Omaha, Nebraska, December 8 and 9, 1927.

In a recent paper by Cathcart the relationship between muscular strain and tuberculosis of the epididymis is exploited, emphasis being given to the medicolegal aspects of the subject. In Cathcart's case the patient was suffering from tuberculosis of the epididymis and sued for compensation on the ground that the disease had arisen after a severe strain in the course of his work. The decision in this case turned upon the answers to two important surgical questions. The first and crucial one was whether or not a severe muscular strain of the abdominal wall can, within an hour or two, set up an acute orchitis and epididymitis apart from any direct injury to the parts and in the absence of any gonococcal infection of the urethra. The second was whether or not such an attack of acute inflammation could be the exciting cause of subacute tuberculosis of the affected parts.

Cathcart concluded that acute orchitis and epididymitis may be caused by severe abdominal strain without gonococcal or other organismal infection of the urethra or the parts affected; that the acute inflammation is sometimes the result of torsion of the cord; and that the acute orchitis and epididymitis thus produced may end (a) in an active tuberculous affection of the epididymis, either by exciting a latent focus of tuberculosis or by giving rise to the conditions suitable for the development of a new focus; or (b) in complete atrophy of the testicle. In the case that formed the basis of Cathcart's paper the sheriff ruled that the claimant had "not proved his case."

Trauma as an etiological factor may be classified under the following headings: (1) direct, (2) localizing, and (3) mobilizing.

1. Direct trauma. By this is meant the direct implantation of tubercle bacilli into the epididymis. This probably never occurs in the production of the disease and is more theoretical than real, hence should not be considered as a factor.

2. Localizing trauma. A number of authorities believe that the rôle played by trauma is purely one of localizing the tubercle bacilli, hence a definite period of time must elapse between the injury and the development of the disease. One of the fallacies of this theory in its application to a given case is the great variation in time between the injury and the onset of the disease. In the present series there were 30 cases in which there was a history of trauma, 47 cases in which there was no history of trauma, and in 17 cases the records failed to state this point.

For years the theory of localizing trauma has had many adherents. As a result of the injury to tissue following the trauma, its resistance is so greatly reduced that a *locus minoris resistentiæ* results and a suitable landing place is effected for the tubercle bacilli circulating in the blood stream. The local hæmorrhage and the presence of necrotic tissue provide a suitable culture medium. The absorption of bacilli is hence interfered with because of the interference with the blood and lymph circulation following the trauma. The weak point of this theory is the fact that nothing is known of the condition of the testicle and epididymis *prior to the injury.*

Many authors refuse to accept the explanation in regard to localizing trauma, among them Cathelin, Jeanbrean, and others, who hold that the tuberculous process was present in every instance at the time the injury was received.

3. Mobilizing trauma. Many clinicians believe that the question of trauma is concerned purely with a mobilizing trauma and that the injury, either direct or indirect, reaches a focus of tuberculosis heretofore not recognized, hence its presence has not been revealed. The trauma causes an acute flare up or causes the tuberculous process already present to become worse. For example, a well developed tuberculous process is discovered in an epididymis immediately after an injury, in which case the trauma simply served as a means of recognizing the tuberculous process. These views are subscribed to by many clinicians, notably, Cathelin, Jeanbrean, Morton, and others.

In the light of these various theories, it is interesting to note the statements made by patients from the standpoint of time that had elapsed between the injury and the onset of the disease. In one instance there was an antecedent history of an injury to the right testicle 18 years before the patient came under observation and 6 years later the testicle was

removed for tuberculosis. In another case the patient fell and injured the right testicle 17 years before and the testicle was removed 1 year after the injury. In another case the patient fell from a tree and injured the left testicle, which subsequently underwent abscess formation. There were 24 cases in which the patients gave a definite history of injury to the testicle which became the seat of tuberculous disease. Unfortunately, a history of trauma was not elicited in many of the early cases.

Another factor, namely, the various types of injuries which preceded the development of the tuberculous disease is of interest. Because of the possible medicolegal aspect of this question in connection with the Workmen's Compensation Acts these types are listed.

Types of injuries mentioned as preceding the onset of the disease: fell at work, pinched by trousers, strain from moving machinery, struck with pick handle, fell from a tree, hit by box, injured in football game, strain in pulling cable, dog jumped at patient, fell astride a log, throwing bales of hay, shrapnel wound over thigh, hit testicle and later ran for a car, fell on a truck, taking child on lap, gunshot wound in hip, kicked in hip, playing when a child, fell off hay loft. In other cases only an indefinite statement regarding strain, such as that due to heavy lifting, etc., was made.

PREVIOUS VENEREAL DISEASE

In view of the fact that tuberculosis of the epididymis may be confused with syphilis and that differentiation from syphilis is necessary, it is interesting to note that there was a positive history of syphilis in only 5 cases. The early cases have no record of any Wassermann tests, but the late cases, because the Wassermann test has been done in recent years as a routine measure, have a record. In this series there were 45 cases in which Wassermann tests had been made, but in only 5 cases was a positive reaction reported, and in these cases syphilis was only an incident, since the histological examination showed that the process was fundamentally due to tuberculosis and not to syphilis.

In all probability gonorrhœa plays a less important rôle than was formerly supposed. Certainly a large number of patients develop tuberculosis of the epididymis who have never had gonorrhœa. In this entire series there were only 27 cases that gave a history of an antecedent attack of gonorrhœa. A history of a previous attack of epididymitis was obtained in 25 cases. In some instances this occurred during a gonorrhœal infection and in some it occurred in the absence of a recent gonorrhœal infection, as far as it was possible to determine. In the latter type of case the epididymitis may have been due to an old nonspecific seminal vesiculitis.

This part of the patient's history should be gone into carefully, and all statements should be accepted or rejected according to their value. Thus in a given case in which the patient states that he had a previous attack of epididymitis, one must determine, if possible, whether the attack was secondary to an old seminal vesiculitis or whether it was a tuberculosis of the epididymis that had subsided and had remained dormant until recently fanned into activity.

On the other hand, a condition much more difficult to interpret may be encountered in which a patient with a latent tuberculosis of the epididymis, which is not known or recognized by him, acquires a gonorrhœal infection, during the course of which he develops an epididymitis. If a gonorrhœal infection is superimposed upon a tuberculous infection it may be the direct underlying reason why the tuberculous infection is not at first recognized. The only possible differentiation then is the unusually prolonged course of the supposed acute gonorrhœal epididymitis. One of our cases presented this picture and the situation was confusing for a short time.

RÔLE OF PHYSIOLOGICAL CONGESTION

It is generally admitted that the largest number of cases of tuberculosis of the epididymis occur between the ages of 20 and 40 years, the period of life when there is the greatest sexual activity and a corresponding increase in the blood supply. Whether or not this factor plays any decided rôle is still an open question.

PRESENCE OF TUBERCULOSIS ELSEWHERE IN THE BODY

In view of the fact that it is generally assumed that tuberculosis of the epididymis is always a secondary process, it behooved us in studying our cases to search very carefully for the presence of tuberculous disease in other parts of the body.

Nothing is so important as an aid in establishing a diagnosis of tuberculosis of the urinary or genital tract as the elicitation of a good, accurate history. From the history one often obtains information relative to previous attacks of tuberculosis in other organs or in a history of surgical operations for tuberculous disease and finally the patient may volunteer the statement of being under treatment at the present time for tuberculosis elsewhere in the body.

Extrapulmonary tuberculosis. In the early cases in this series not enough emphasis, unfortunately, was placed upon this part of the history, and some of the records do not mention anything about antecedent tuberculous disease. In a review of this series, however, evidence of antecedent tuberculous disease was obtained in 15 cases with the following distribution: tuberculosis of the kidney in 10 cases, of the kidney and hip in 1 case, of the spine in 2 cases, of the shoulder in 1 case, and of the glands in the neck in 1 case.

Tuberculosis of the lungs. In all of the later cases great emphasis was placed upon trying to determine whether the patients had any evidences of pulmonary tuberculosis. In some of the cases it was rather easy to obtain a history of antecedent tuberculosis, such as protracted cough, night sweats, or a history of pleurisy. Particular stress was placed upon this point so as to determine lung involvement and it was interesting to note that in a certain number of cases the internist had declared the lungs negative and the roentgenologist had reported the evidence of an old healed tuberculous disease. Nevertheless, the most important point is to determine whether or not there is lung involvement. Whether the diagnosis is made by one or both methods is irrelevant.

If we include in one group, cases in which the diagnosis of pulmonary involvement was made, both clinically and roentgenologically, we find that in 75 cases, or 79.8 per cent, either the clinical or the X-ray examination showed evidence of tuberculosis, either active or healed. Involvement of the bones was found to be present in 4 cases; the spine in 2 cases, the shoulder in 1 case, and the hip in 1 case.

RECTAL FINDINGS

The information obtained in this series by means of rectal examinations agrees in the main with the conclusions reached by Barney and others in connection with this phase of the subject. The value of the rectal examination must always remain subject to a certain amount of criticism. If the rectal examination is positive, well and good, but, on the other hand, a negative rectal examination does not necessarily mean that there is not a small focus of tuberculosis either in the prostate or vesicles. It is obvious how one might miss a tuberculous nodule in the prostate or vesicles on rectal examination under certain circumstances.

The statistics of Cunningham, who autopsied a large series of cases, are of interest. In his series of 4,250 autopsy records he found 35 instances of tuberculosis of the epididymis and in 25 (nearly 71.42 per cent) of these the prostate and vesicles were involved. In his series of 86 clinical cases 49 (nearly 57 per cent) gave positive findings.

It should be remembered that frequently an early examination may prove negative, while a later one may disclose evidence of associated disease at this point. In our 94 cases there were 85 in which the results of the rectal examination were recorded, but in 9 cases this information is lacking. Of the 85 cases there were 70 in which the records showed positive changes in the prostate or the seminal vesicles or in both. Naturally the largest number of positive cases occurred late in the course of the disease. If we reduce the number of positive rectal findings, we have 82.35 per cent of positive findings. These figures tally with those of Barney. In his series of 101 rectal examinations of patients with tuberculous epididymitis, he recorded the prostate as being tuberculous in 76 cases,

or 75 per cent. I believe that his estimate of 75 per cent is conservative.

ONSET

By far the largest number of patients with tuberculous epididymitis had a slow gradual onset and the disease, as a rule, began long before the patients came under observation. Often the patient had no pain and discovered a nodule quite by accident or often the nodule was discovered during a routine physical examination so that the patient was unable to say just when the tuberculous process began. On the other hand, in many instances, a very definite date of onset was given (Table II).

TABLE II.—ONSET

Duration of symptoms in years	Cases
1 or less	52
2	13
3	11
4	6
5	1
6	1
9	1
10	1
12	1
18	1
Not stated	6
Total	94

SIDE INVOLVED

It is the general consensus of opinion that tuberculosis involving one epididymis is followed sooner or later by an involvement of the opposite side so that eventually both sides are the seat of the tuberculous process. In this series of 94 cases there were 37 in which there was a subsequent involvement of the opposite side or reduced to terms of percentage equals 39.36 per cent. Barney in his series found that in 41.6 per cent the opposite side became involved. By means of a very careful survey of this series and by personal examination of the patients, or, where this could not be done, by personal correspondence, it was found that there were 48 cases in which no subsequent involvement of the other side took place and 9 cases in which no statement relative to this question was obtained. There were 4 cases in which there was bilateral involvement when the patients presented themselves for examination and in which the process began on one side, and these added to the 33 that had involvement of the other side makes the total number of bilateral cases 37, or 39.36 per cent. It is very interesting in the study of the question of involvement of the opposite side to note the large number of cases in which this involvement took place rather early. In this series, involvement of the other side occurred in 15 cases during the first 6 months and after 6 months in 17 cases. No time was mentioned in 5 cases. There does not seem to be much difference regarding the sides involved. In 48 cases the patients presented involvement of the right side, in 41 cases of the left side, in 4 cases of both sides, and there was no record in 1 case.

SYMPTOMS

It was to be expected that these patients would have more or less pain. As a rule, the pain was referred to the testicle, but, strictly speaking, it was not limited to the testicle. In 16 cases in this series it was referred to as being along the cord and in 8 cases it was referred to the groin. Some of the patients complained of pain in the thigh and occasionally in the scrotum. Therefore, too much dependence should not be placed on the patient's statement with regard to the location of the pain.

Urinary symptoms. Early in the course of this disease there was rarely, if ever, a reference to urinary symptoms. Thus in 43 of the 94 cases in this series, or 45.7 per cent, there were no urinary symptoms. Gradually, however, many patients complained of various urinary symptoms. The urinary symptoms depended in part upon whether the tuberculous process began in the epididymis or in the kidney. For example, when the tuberculosis of the epididymis followed a tuberculosis of the kidney, many of the urinary symptoms were due to involvement of the bladder, and often the symptoms of tuberculous cystitis were present before the onset of the tuberculous epididymitis; but, when the patient reported for examination for tuberculous disease in the epididymis, he would naturally mention the fact that he had urinary symptoms. In another group of cases in which there was no higher involvement in the urinary tract and

in which instance the urine showed only a few leucocytes, urinary symptoms were present, due, no doubt, to manifestations of tuberculosis in the prostate or in the seminal vesicles or in both. In some of these cases more than one urinary symptom was present. Table III shows the most frequently mentioned symptoms.

TABLE III.—SYMPTOMS

	Cases
Frequency	42
Hæmaturia	23
Burning	22
Painful urination	21
Backache	17
Fever	10
Urgency	9
Difficulty	8
Incontinence	4
Dribbling	3

Urinalysis. The urinary findings in this series of cases are extremely interesting in that they show the presence of abnormal elements in the urine in a large number of cases. The presence of pus in the urine varied within rather wide limits. In some of the cases in which the tuberculous process in the epididymis was secondary to an advanced urinary tuberculosis, the patient had urinary findings of much more serious moment than were found in the cases before there was much involvement of the urinary tract. The striking thing about reviewing the urinalysis in this series is the fact that in 72 of the 94 cases, some pus was found. Table IV shows the results of the urinary examination.

TABLE IV.—URINALYSIS

	Cases
Pus	72
Albumin	39
Red blood cells	23
Bacteria	9
Casts	7
Tubercle bacilli (either on smear, guinea pig inoculation, or both)	13

ABSCESS FORMATION

In a certain number of instances the tuberculosis progresses and abscess formation occurs. In this series of 94 cases, abscess of the epididymis was found in 30 cases. Often the abscess ruptures externally or is opened surgically and a scrotal fistula results.

VAS DEFERENS

One of the diagnostic points that has been mentioned from time to time is the condition of the vas deferens, the statement having been made that unless there is some evidence of pathological changes in the vas deferens the patient does not have tuberculosis of the epididymis. This probably is a good clinical rule to follow since in 94 cases in this series 55 had involvement of the vas deferens. In 63 cases in which this point was mentioned, it was positive in 55 cases, or 87.3 per cent, negative in 8 cases and in 31 cases was not mentioned. It may be that the percentage of cases in which there was involvement of the epididymis was higher than is apparent from these figures. There can be little doubt as to the fact that if a tentative diagnosis of tuberculosis of the epididymis is made and the patient does not present involvement of the vas deferens, one should be cautious in making a diagnosis of tuberculosis. Failure to heed this advice in one case led to the wrong diagnosis; a diagnosis of tuberculosis of the epididymis was made and attention was called to the fact that the vas was not involved. This should have cautioned us to change our diagnosis, but we did not. At the operation a tumor of the testicle was found. Barney, in a paper read at a meeting of the American Association of Genito-Urinary Surgeons, has already called attention to the confusion in this differential diagnosis.

SCROTAL FISTULA

As is well known, one of the diagnostic points in favor of tuberculosis is the presence of a single fistula or multiple fistulæ in the scrotum, which are either unilateral or bilateral. Not uncommonly the patient states that these fistulous tracts discharge purulent fluid for a while, close, and then reopen. In this series, fistulæ were found in 33 cases, none was found in 54 cases, and in 7 cases no record was made as to their presence. Hydrocele fluid was found present in 18 cases.

END-RESULTS

Of great interest, as mentioned previously in this paper, are the ultimate end-results, because of their importance from the stand-

TABLE V.—LATE CAUSES OF DEATH IN CASES OPERATED UPON

	Cases
Tuberculous meningitis	5
Pulmonary tuberculosis	4
Miliary tuberculosis	2
Tuberculosis of genito-urinary organs	1
Paralytic ileus following operation for nephrectomy 1 year 8 months later (patient operated upon elsewhere)	1
Tuberculous peritonitis	1
Accident	1
Cause unknown	1
Total	16

TABLE VI.—LATE CAUSES OF DEATH IN CASES NOT OPERATED UPON

	Cases
Miliary tuberculosis	3
Tuberculous meningitis	2
Pulmonary tuberculosis	1
Pernicious anæmia	1
Nephritis	1
Unknown	2
Total	10

TABLE VII.—DURATION OF LIFE AFTER OPERATION IN PATIENTS NOW DEAD

Years	Cases
Less than 1	5
1 to 2	4
3 to 4	2
4 to 5	4
12	1
Total	16

TABLE VIII.—DURATION OF LIFE AFTER EXAMINATION IN PATIENTS NOW DEAD AND NOT OPERATED UPON

Years	Cases
Less than 1	4
3	2
11	1
12	1
No report	2
Total	10

point of prognosis. After a diagnosis of tuberculosis has been established, what may the patient look for from the standpoint of life expectation? This question has been of interest not only to the patient and his family, but for the life insurance company as well. After a diagnosis of tuberculosis has been made, what sort of a rating should the patient receive from the company?

TABLE IX.—DURATION OF LIFE AFTER EXAMINATION OF PATIENTS NOW LIVING AND NOT OPERATED UPON

Years	Cases
1¼	1
2½	1
4	1
5½	1
10	1
17½	1
Total	6

TABLE X.—DURATION OF LIFE AFTER OPERATION IN PATIENTS STILL LIVING

Years	Cases
1 or under	7
2	5
3	4
4	7
5	6
6	3
7	9
8	2
9	3
10	1
11	5
12	1
13	2
14	1
15	1
Total	57

TABLE XI.—CONDITION OF PATIENTS NOW LIVING WHO WERE OPERATED UPON

	Cases
No symptoms	36
Bladder symptoms	5
Developed tuberculosis of kidney and spine	1
Developed pulmonary tuberculosis	1
Developed tuberculosis of kidney	1
Developed a sinus which is still draining	1
Second side became involved 2 years after operation. No symptoms	1
Second side became involved 1½ years after operation and operated	1
Several years after operation lost use of arms and legs. Blood pressure 220-85	1
Ulcer in middle of Poupart's ligament	1
Incontinence. Sinus in both sides	1
Developed tuberculosis of both kidneys and bladder. Symptoms have not subsided	1
Reported well 2 years after operation	2
Under observation (late cases)	3
Living but no report on condition	1
Total	57

In reviewing the cases a study was made to determine whether or not patients who were operated upon lived longer than those who were treated without surgery, whether the

patients who were operated upon had different deaths from those who were not operated upon, and finally to determine the cause of death.

In this series 78 patients were operated upon and of these 78 patients 16 are dead and 57 are living. The results in 5 cases are not known. There were no immediate deaths, but the conditions causing death occurred at varying periods after the patients left the hospital (Table V). The three most frequent causes of death in this group are tuberculous meningitis, pulmonary tuberculosis, and miliary tuberculosis.

In the fatal cases not operated upon, although the total number is only 8, we see a somewhat similar but not exactly parallel cause of death (Table VI). The two most frequent causes of death in this group are miliary tuberculosis and tuberculous meningitis, while in the other group, the two most frequent causes were tuberculous meningitis and pulmonary tuberculosis.

TABLE XII.—CONDITION OF PATIENTS NOW LIVING AND NOT OPERATED UPON

	Cases
Treated with tuberculin. No symptoms	2
No treatment. No symptoms	3
No treatment. No improvement	1
Total	6

One patient who died 16 days after epididymectomy had a very advanced case of pulmonary tuberculosis. He was operated upon under local anæsthetic for multiple fistulæ which were discharging great quantities of pus. The operation was principally undertaken for the purpose of giving the patient some degree of comfort.

One of the patients not operated upon lived 11 years after the diagnosis of tuberculosis of the epididymis had been made. He finally died of pernicious anæmia (Table VIII).

THE DIFFERENTIATION OF THE REDUCING BODIES IN THE URINE DURING PREGNANCY

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In clinical laboratory work, urines are frequently brought to the laboratory with the statement that a reducing body has been found and a request is made for a decision as to the type of carbohydrate which is present. These requests seem to come most often from the obstetrical service since it is occasionally of clinical value to determine whether or not the reducing substance is glucose or lactose.

An analysis of the situation shows that the obstetrician really desires the answer to certain questions: (1) is the reducing body a sugar; (2) if it is a sugar, is it glucose or lactose; and (3) if the sugar is glucose, is the patient a diabetic or is she suffering from only a harmless glycosuria?

The last question is really the only one of importance. If the patient is a diabetic, she must be treated as such. All the other conditions can be ignored. Fortunately, true diabetes in pregnancy is rare, but it is extremely important to pick out the occasional case.

The first question is the most difficult to answer in a hospital laboratory, since a number of non-carbohydrate reducing substances may be present and the exact structure of most of these is not known. As a rule, therefore, the first question is answered by exclusion after the second and third are solved. If one can exclude glycosuria and lactosuria, and the reducing substance is present in small quantities, the assumption is that we are dealing with a non-specific reduction.

In attempting to answer the second question, we also run into many laboratory difficulties. When we examine methods available for the identification of the type of carbohydrate in urine, we find that there are only two which are practically applicable in the clinical laboratory: the fermentation and the phenylhydrazine test. Both of these tests are subject to certain very definite limitations which must be clearly understood by the clinician in the interpretation of the results. It should be realized that from these two tests the laboratory cannot absolutely identify the type of carbohydrate but can give only an approximate result.

First, only one strain of yeast has ever been identified which ferments glucose exclusively without splitting some other carbohydrates, and this culture has been lost. Second, yeast also contains a decarboxylase which at times can split the amino-acids present in urine with the production of gas. Again, bacteria may be present which will split lactose to galactose and glucose, and thus allow the latter to be fermented by yeast. Galactose itself is fermentable to a small extent. In addition, the quantity of the yeast and the time during which it acts must be regulated since the respiration of large quantities of yeast may form some carbon dioxide from glycogen. Finally, some samples of yeast may contain a small amount of diastase, and this acting upon the constituents of yeast may produce a minute amount of sugar at incubator temperatures.

In the case of the phenyl osazones, it is not possible to make an absolute identification from the morphology alone. To be sure of the osazone it is necessary to make an accurate determination of the melting point, and since the melting points of the common osazones lie close together, this is a matter of considerable difficulty and beyond the scope of the ordinary hospital laboratory. In urine, the colloids which are present often prevent the formation of the osazone entirely or alter its morphology. This is particularly true as regards lactose. It should be remembered also that levulose which is sometimes found in urine gives the same osazone as glucose.

In view of these various uncertainties, it seemed desirable, in order to determine just how reliable or unreliable are the reports from the laboratory, to evaluate more carefully these two methods both from the stand-

point of performing the test and of correlating the results with the clinical findings in a series of cases.

At one time, every obstetrical patient in the University Hospital had a routine urinalysis once a week. Each specimen of the urine which showed a yellow precipitate with Benedict's solution was taken to the central laboratory for further test. Specimens which showed only a greenish color without a yellow precipitate were discarded. During this period, 556 specimens were examined and of these 160, 28 per cent, showed a yellow precipitate and were further examined. A comparison of the results of the tests was made with the clinical condition of the patients, particularly with regard to whether they were secreting milk or colostrum.

Host has made a careful study of the various techniques employed for these two tests and has developed a new standard technique which we have used throughout our work. It should be understood that our results should be considered as results secured only with this technique. Host showed that the test carried out with phenylhydrazine hydrochloride is less sensitive than with phenylhydrazine since from ½ to 1 per cent of glucose must be added to normal urine before it is positive with the former reagent while the phenylhydrazine will secure positive results with concentrations of from 0.1 to 0.2 per cent of glucose in urine. The details of the methods are given below.

For the fermentation of urine bring the hydrogen-ion to 5.5 or 6.8°. This is best done by testing with brom-thymo blue against the Clark standards. The reaction can be adjusted if necessary by the addition of tartaric acid or sodium bicarbonate. Boil the urine to kill organisms which might affect carbohydrates. Cool, then add fresh yeast so as to make an approximately 5 per cent suspension. Host recommends reading after 48 hours in the incubator. We have found that incubation for this length of time results in a large number of non-specific fermentations and believe that the period of from 12 to 24 hours which is more commonly in use in this country is more accurate. As a matter of fact if large quantities of glucose are present, gas is formed in a very short time.

For the phenylhydrazine test, place about 4 cubic centimeters of urine in a test tube and add 1.5 to 2 cubic centimeters of a saturated solution of sodium acetate in 50 per cent acetic acid and 3 drops of phenylhydrazine. This is brought to the boiling point and the tube is then put in a water bath at 100 degrees C. for about an hour. The test tube is allowed to remain in the water bath so as to cool slowly and is not examined microscopically until the next day.

We have found the widest variation in the morphology of the osazones particularly the lactosazones and it was only because we had seen so many intermediate forms that we were able to identify them in some of the specimens. The small ray-like fibers characteristic of lactosazone tend to disappear leaving small, round, dark globules with a smooth rim.[1]

The physiological osazone described by Host was observed in a few cases but all of these occurred early in the series and none was seen later. Some minor changes in technique or seasonal change in diet seems to be an added factor in their production.

Osazones of unknown type were seen in 5 urine specimens of lactating women. Two of these were irregular sheaf-of-wheat forms and these might possibly have been atypical glucosazones. In one, the osazones appeared much like sunflowers with regular dark centers and long, broad, regularly-arranged rays. In another, regular light brown bodies without spicules were seen. These were quite similar in morphology to a group of osazones which were produced by testing the non-fermentable residue of molasses. Still another specimen showed many small dark osazones arranged closely together like bunches of grapes but without any spicules or projections.

Matthews has recommended a rapid method of fermenting urine by the use of much larger quantities of yeast acting over a shorter time. We have tried this method on other occasions and found it satisfactory but in specimens such as those in this series when only small quantities of reducing substance are present, it gives non-specific results since the reducing body in the urine is destroyed by yeast. Thus in specimens from 15 patients which showed no fermentation by the ordinary test, the Matthews test destroyed all of the reducing power in 12, thus pointing to the presence of glucose. The reducing power remained after fermentation in 2 and was doubtful in 1 case.

[1] Much of the technical work in connection with this paper was done by Dr. W. S. Scott and Mr. Adam Szczypinski. The final readings and reports, however, were all made personally by one of the authors.

TABLE I.—COMPARISON OF TYPE OF CARBOHYDRATE WITH PERIOD OF LACTATION—ONE HUNDRED AND SIXTY CASES

	Lactating	Colostrum	Not Lactating
I. Fermentable specimens:			
Osazones			
No osazone (found)	1	0	0
One—glucose	1	1	0
II. Not fermentable specimens:			
Osazones			
Test not done	15	4	0
None	36	15	1
One—Lactose	54	14	2
One—Glucose	1	1	0
One—Physiological	1	5	0
One—Unknown	3	0	0
More than one osazone:			
Physiological and lactose	2	1	0
Unknown and lactose	2	0	0
Total	116	41	3

Cammidge believes that, by absorbing the lactose from urine with a high grade of blood charcoal, lactosazone can be more easily obtained. In 7 cases in which no osazones were found by the ordinary technique, none was found by the charcoal method and in 1 case lactosazone was found by the ordinary method and not by the charcoal method.

Only few glycosurias occurred in our series so that the major portion of our work has been concerned with the identification of non-fermentable carbohydrate. From our own observations in glycosurias in non-pregnant cases and from the literature we can say that a markedly positive fermentation test under standard conditions usually means glucose. When only small quantities of reducing substance are present the difficulties of interpretation are greater. Thus it should be noted that in our series the urines of 2 patients showed glucosazones but they did not show more than a trace of fermentation. All glucosazones came from patients with glycosuria as there were no true diabetics in this series.

The formation of lactose by the body is intimately connected with the period of the formation of milk. Colostrum has also been shown to contain lactose in varying quantities. Table I shows the results of a comparison of our findings arranged according to the period of lactation. It will be seen that in the group of non-fermentable carbohydrate, in only about one-half of the cases could lactosazone be identified morphologically. The presumption is that most of these reducing bodies should have been lactose. Whether this group which did not form osazones represents lactose which cannot be identified because of interfering substances in the urine or some other type of non-fermentable carbohydrate cannot be determined through this study, but the former supposition is inherently more probable. An arrangement of the non-lactating and colostrum cases is made in Table II chronologically in the course of their pregnancy. We had relatively few cases early in pregnancy.

We may conclude therefore that if a marked fermentation occurs we are probably dealing with glucose. If an osozone of characteristic morphology is observed, it is probably fairly specific but other combinations of results are inconclusive. Therefore, because of the technical difficulties which we have encountered in these two tests, it would seem from the literature and from our findings that too much reliance should not be placed by the clinician upon them.

Fortunately, certain clinical short cuts are of help in connection with this problem and may be used to avoid a great deal of unnecessary laboratory work. Thus Williams, using the fermentation test, has shown that glucose is found 5 times as commonly in the last half of pregnancy as in the first half and that a reducing body found during pregnancy is practically always glucose and not lactose. However, during the period of breast engorgement, lactosuria is present in a considerable proportion of nursing women. This is due to the fact that lactose is formed in the human body only during the period in which colostrum or milk is being formed in the breast. Our data in Table II (non-lactating and colostrum cases) does not, however, support his general statement that "not a single specimen taken during pregnancy showed the persistence of a sugar reaction after fermentation, demonstrating that the sugar found in the urine during pregnancy is always glucose."

This discrepancy is probably due to the fact that Williams' series contains many cases observed during the early months of pregnancy while most of our cases were studied from the ninth month on. In fact only 3 of our cases showed neither colostrum nor milk in the breast. The 2 series should therefore be considered as a whole representing 2 phases of the same problem. Thus as a ready rule of thumb, it may be stated that a reducing body in the urine during pregnancy is lactose if the breasts are secreting and glucose if they are not, particularly in the earlier months of pregnancy.

In answering the third question at the beginning of the paper as to the means of differentiating glycosuria from diabetes, Host offers considerable help in his work in which he studied the glycosuria of pregnancy by means of the sugar tolerance test. He showed that early in pregnancy (from 1 to 3 months) the glycosuria is of the hæmic type, that is, there is no change in the renal threshold but there is some defect in the storage mechanism for glucose, so that the blood sugar rises over the threshold and is therefore excreted in the urine. During the latter part of pregnancy, on the other hand, the blood-sugar rise is usually small but the renal threshold is often so low that glycosuria of the renal type frequently occurs.

After the determination that the reducing substance is glucose, the next step in the differentiation of a glycosuria from a case of diabetes consists in the estimation of the fasting blood sugar. If this is elevated, it points to the presence of diabetes. If it is normal a glucose tolerance test is necessary for final differentiation. Since this is costly in time and money both to the patient and to the hospital it should be used in as few cases as possible. Clinically a patient with glycosuria, particularly if it is not more than a few grams in 24 hours, who has no diabetic symptoms such as polydipsia or polyuria, who has lost no weight, who has no acetone bodies in the urine, and who has a normal fasting blood-sugar, can be considered for all practical purposes to be non-diabetic. This is particularly true in cases in which the glycosuria clears up after delivery.

TABLE 11.—COMPARISON OF TYPE OF CARBOHYDRATE WITH DURATION OF PREGNANCY—NON-LACTATING AND COLOSTRUM CASES

	Before delivery				After delivery		
	At term	36-38 weeks	32-36 weeks	28 weeks	Full term spontaneous	Abortion	Cæsarean at term
Fermentable specimens:							
Osazones							
Glucose	1	0	0	0	0	0	0
Not fermentable specimens:							
Osazones							
Test not done	1	0	2	0	0	1 (24 wks)	0
None	7	5	0	1	2	1 (24 wks)	0
One—Lactose	6	4	0	0	3	2 (28 wks)	1
One—Glucose	1	0	0	0	0	0	0
One—Physiological	2	1	0	0	1	1 (18 wks)	0
More than one osazone							
Physiological and lactose	1	0	0	0	0	0	0
Total	19	10	2	1	6	5	1

We may say, therefore, that in the majority of cases:

1. A reducing body found in the urine of a pregnant woman during the period of breast engorgement is probably lactose rather than glucose.

2. A reducing body found in the urine of a pregnant woman during pregnancy and before the period of breast engorgement is probably glucose rather than lactose.

3. Glucose found in the urine during pregnancy is almost always due to a glycosuria of renal or hæmic type rather than to a diabetes.

SUMMARY

1. Twenty-eight per cent of a series of urines from pregnant women showed reduction by the Benedict test.

2. Osazones of unknown type occurred in 5 cases.

3. The fermentation test according to the method of Host gives more specific results than does that of Matthews.

4. The charcoal method of isolating lactosazones was not successful in the few cases in which it was employed.

5. In only about one-half of the non-fermentable specimens was it possible to isolate lactosazones. These came from patients with both milk and colostrum in the breast and from 2 non-lactating patients.

6. Certain clinical rules are given which seem to be sufficiently accurate to follow in the average case, and the laboratory work should be ordered only in the occasional difficult case and then accepted with a certain amount of reserve; a negative hydrazine test may mean only some interference with the formation of visible crystals of lactosazone.

BIBLIOGRAPHY

1. Cammidge, P. J., and Howard, H. A. New views on diabetes mellitus. Oxford Medical Publications, 1923, 163.
2. Host, H. F. Carbohydrate tolerance in pregnancy. Lancet, 1925, i, 1022.
3. Idem. The urine sugar and its relation to blood sugar. J. M. Res., 1922, iv, 315.
4. Matthews, A. P. An easy method for the distinction and estimation of lactose and glucose in urine. J. Am. M. Ass., 1920, lxxv, 1568.
5. Williams, J. T. Some observations upon the glycosuria of pregnancy. Boston M. & Surg. J., 1925, cxcii, 163.

DANGERS IN THE POSTOPERATIVE USE OF INSULIN[1]

By EDMUND ANDREWS, M.D., F.A.C.S., and KNUTE REUTERSKIOLD, M.D., Chicago

ALMOST immediately upon the discovery of insulin and its value in the treatment of diabetes, attempts were made to use it in non-diabetic conditions. Within the last 5 years an enormous literature has grown up on the use of insulin in the treatment of various postoperative conditions and if the literature is any indication, the use of insulin must be very wide-spread in the surgical clinics today. There appeared in 1923 the pioneer work of Thalhimer (21). His work was elaborated by Fisher (11) in several reports tabulating 45 cases treated by this method. Subsequently others appeared to confirm the value of this treatment (10). Many patients were apparently benefited although the results were not uniform, but as Fisher warned us certain untoward effects were observed. Therefore, in this form of treatment the blood sugar level should be controlled much more carefully than in cases of diabetes.

A critical review of this literature in the light of modern medical knowledge of insulin action is to say the least not convincing. In the first place the whole rationale of this method is based on the early work of MacLeod (8), Banting (4), and especially of Ringer (19) on the standardization of insulin. Ringer's work on pancreatectomized animals showed that one unit of insulin will bring about the oxidizing of one gram of glucose based on the studies of the respiratory quotient.

The more modern viewpoint is that the action of insulin is much more indirect. The recent article of Eadie (15) and MacLeod (15), make it exceedingly doubtful that insulin is concerned in any manner with glycolysis. It has been shown beyond a doubt that the combustion of glucose within the muscle is not increased by the action of insulin *per se*. The actual physiological effect of insulin appears to be three-fold:

1. It promotes the storage of glycogen in the liver.

2. It converts glucose into some other hexose more readily oxidizable.

3. It brings about an increased affinity of tissue for water, thereby causing a concentration of the blood.

In two previous articles (2, 3), it was shown by one of us that the action of insulin was enormously exaggerated and prolonged if the organism was markedly dehydrated. Doses of insulin which under normal conditions produced a slight fall (15 milligrams of blood sugar lasting for 2 hours), would cause a profound and even dangerous hypoglycæmia in dehydrated animals. The theoretical consideration of this phenomena are discussed at greater lengths in one of these papers.

EXPERIMENTAL

With this point in view the action of insulin after operations was studied in a number of patients. Blood sugar estimations were made by Byrd's modification of Folin Wu. By this method blood sugar estimations can be made by 0.1 of blood and by making estimations every 15 to 30 minutes, all the details of the curves become evident.

Ether anæsthesia cases only were used. Twelve to eighteen hours after operation, at the height of the reaction, 10 units of insulin were given subcutaneously. (Lilly Iletin units 20) and 25 grams of glucose.

Curve 1 is a composite curve of the effect of 10 units of insulin and 2½ grams of glucose per unit (25 grams) in normal human beings. The result, as can be seen, is about a 15 milligram drop in blood sugar with a return to normal within 2 hours. If the results of insulin and glucose after operation were comparable to this it would be a highly valuable procedure. However, the dehydration which results from the starvation and the acidosis accompanying practically every surgical procedure results in a profound and dangerous hypoglycæmia.

Curve 2 illustrates this point. The insulin and glucose were given the morning after the

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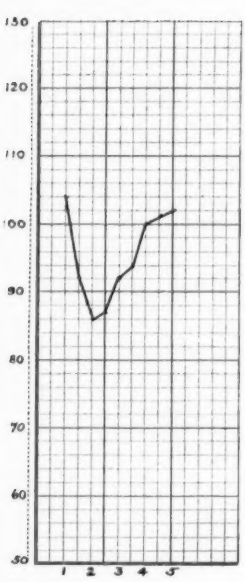

Chart 1 (left). Composite curve of effect of 10 units of insulin and 2½ grams of glucose per unit in normal human beings.

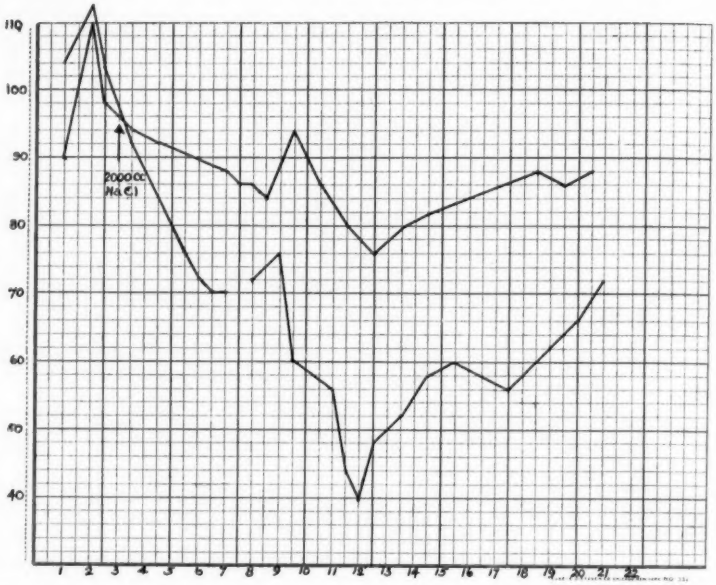

Chart 2. Insulin and glucose were given on the morning after operation. In the second curve the patient had been given 2,000 cubic centimeters by hypodermoclysis.

operation. The blood sugar was already low as a result of the 24-hour starvation. The resultant fall in blood sugar was rapid and profound. The injections had been given at 8 o'clock in the morning and by 1 o'clock in the afternoon it was 39 and the patient had begun to twitch. He was then rescued by the administration of glucose.

The other curve represents a similar experiment on a patient who had been flooded with 2,000 cubic centimeters by hypodermoclysis, and it will be seen that the insulin effect was slight and transient.

Curve 3 represents a more accurately controlled experiment. Two curves are given of the blood sugar following herniotomies.

The conditions were identical except that one patient had no fluids except small sips by mouth. The other got very large amounts by proctoclysis and hypodermoclysis (4,000 cubic centimeters). The intensity and length of the insulin action in the two cases is evident. The hydrated man had practically no insulin action. The other had a fall in blood sugar of 35 milligrams which lasted for 13 hours.

Curve 4 shows the practical abolishing of the insulin effect by the administration of 2,000 cubic centimeters of saline following a slight operation.

The lower curve shows that the operation *per se* is not the factor producing this phenomenon. This patient had no operation. He was dehydrated for another purpose, and it is evident that the insulin action is here very markedly exaggerated.

DISCUSSION

It is evident from these curves that the use of insulin and glucose in patients who are suffering from postoperative conditions and are therefore unavoidably dehydrated, is a highly dangerous and useless procedure. It must also be remembered that in toxic conditions, fluids are fixed by colloids and not available for physiological purposes and that the "free" water in the organism is therefore reduced even more than the total water. This condition (fixation of "free" water) is physiologically equivalent to dehydration. What these patients need is glucose and water.

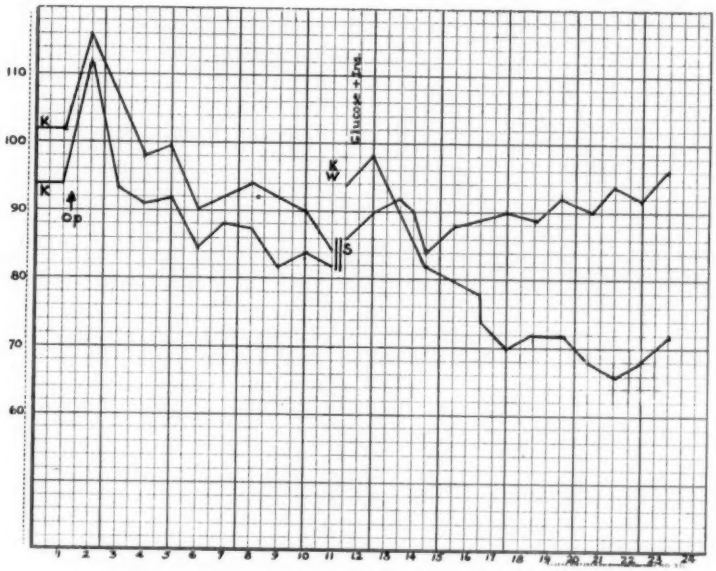

Chart 3. Curves showing blood sugar following herniotomies.

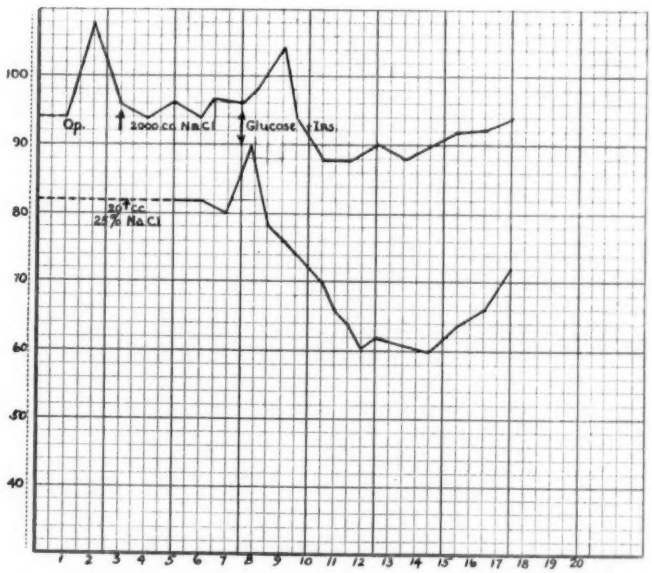

Chart 4. Abolishing the insulin effect by administration of 2,000 cubic centimeters of saline after slight operation.

They are starved and thirsty and have a constant hypoglycæmia, and insulin not only does not produce any glycolysis but it tends to lower the already low blood sugar still further. This insulin hypoglycæmia is not only marked but often reaches the danger point and the symptoms of hypoglycæmia are so similar to many other postoperative complications that their recognition is exceedingly difficult.

In none of the previous reports and experiments on the use of insulin and glucose injections after operation was any careful estimation of blood sugar made, such as was made in the cases reported. One or at most two blood sugar estimations were made. It is very evident from a study of our curves how confusing such a procedure would be. In the first place the ether anæsthesia produced a rise in the blood sugar of moderate intensity, lasting for from 2 to 5 hours. In the next place, insulin injection itself produced a transient rise in blood sugar before the fall began. For these reasons the previous work on this subject cannot be considered of great value.

Another thing to be considered in such work is the so-called Escudero effect (9). If an organism receives glucose, there is first a hyperglycæmia. After this, generally in a few hours, there is a marked hypoglycæmia lasting for several hours. This is due to the fact that the carbohydrate storing mechanism is speeded up by the high blood sugar and continues to overact.

Also to be considered in this connection is the effect of insulin, as already mentioned, of concentrating the blood. Following any operation, there is often a passage of fluids and protein into the tissues and insulin instead of correcting this condition merely tends to exaggerate it, giving rise to a vicious circle. That is, the more the blood is concentrated the more the insulin acts and the more the blood concentrates.

CONCLUSION

In postoperative acidosis and dehydrated conditions, glucose and water are needed. Insulin is not only not needed but its use is definitely contra-indicated.

BIBLIOGRAPHY

1. Anderson, E. M. The use of insulin and glucose in prevention of surgical shock. California & West. M., 1927, xxvii, 56–61.
2. Andrews, Edmund. Sugar metabolism in dehydration. Arch. Int. Med., 1926, xxxviii, 136–141.
3. Andrews, Edmund, and Schlegel, Karl. Effect of varying degrees of hydration on sugar metabolism. Arch. Int. Med., 1927, xi, 637–646.
4. Banting, T. G. Diabetes and insulin. Canad. M. Ass. J., 1926, xvi, 16, 221–232; Förh. Svens. Läk.-Sällsk. Sammank., li, 189–201.
5. Beresow, E. L., and co-workers. Die post-operative Acidosis und ihre Behandlung. Arch. f. klin. chir., 1927, cxliv, 223–237.
6. Buford, R. K. Combined use of insulin and glucose in surgery. West Virginia M. J., 1926, xxii, 240.
7. Clark, O. Insulin treatment in hiccup and persistent postoperative vomiting. Folha med., 1927, viii, 153.
8. Eadie, G. S., MacLeod, J. J. R., Noble, E. Insulin and glycolysis. Am. J. Physiol., 1923, lxv, 462–476.
9. Escudero, P. Latent diabetes. Endocrinology, 1927, xi, 27–33.
10. Falta, W. Insulin und Glukose. Deutsche med. Wchnschr., 1927, liii, 2014.
11. Fisher, D., and co-workers. J. Am. M. Ass., 1924, lxxxiii, 1906–1908.
12. Fisher, D., and Mensing, E. Insulin-glucose treatment of surgical shock and non-diabetic acidosis. Surg., Gynec. & Obst., 1925, xl, 548–555.
13. Fisher, D., and Snell, F. The insulin treatment of pre- and postoperative non-diabetic acidosis. J. Am. M. Ass., 1927, lxxxii, 699.
14. MacLean, H. Insulin in surgery. Proc. Roy. Soc. Med., 1927, xx, 7–14.
15. MacLeod, J. J. R., and Chaikoff, I. L. Effect of insulin on respiratory changes of fed and starved rabbits. J. Biol. Chem., 1927, lxxiii, 725–747.
16. MacLeod, J. J. R., and Markowitz, F. Further researches on depancreatized animals treated with insulin. Tr. Ass. Am. Physicians, 1926, xli, 147–161.
17. Orator, V. Insulin in surgery. Deutsche Ztschr. f. chir., 1926, cxcv, 57–68.
18. Randall, H. E. Insulin and dextrose therapy. J. Michigan M. Soc., 1927, xxvi, 19–21.
19. Ringer, M. J. Biol. Chem., 1923, lviii, 483.
20. Thalhimer, W. Insulin treatment of postoperative (non-diabetic) acidosis. J. Am. M. Ass., 1923, lxxxi, 383–385.
21. Idem. Postoperative treatment with glucose and insulin. Wisconsin M. J., 1922, xxi, 560; 1923, xxii, 230.
22. Tuason, M. N. Insulin-glucose in surgical shock. J. Philippine Islands M. Ass., 1927, vii, 283–286.

HÆMOLYTIC ANÆMIA IN PREGNANCY[1]

By WILLIAM ALLAN, M.D., Charlotte, North Carolina

THE pernicious anæmia of pregnancy is an acute hæmolytic anæmia, which occurs in women under 35 years of age, is due to pregnancy, progresses steadily without remissions to death or recovery, and is curable by blood transfusion. Thus, it differs from Addisonian pernicious anæmia, which is essentially a chronic disease of unknown etiology, occurring after 35 years of age, predominantly in men, is not curable by blood transfusion, and runs a course characterized by remissions.

About 3 per cent of the cases listed as pernicious anæmia (4) occur during or shortly after pregnancy. In the British Isles, this anæmia is seen once in every 2,000 to 10,000 pregnancies. Hoskins (11) considers the condition common in Northern India and McSwinney (14) finds an incidence of 1.69 per cent in one of the Calcutta hospitals. McSwinney's cases were chiefly among Hindus, while in Bombay, Balfour (2) found this anæmia proportionally much more common among Mohammedans, a fact which she attributes to their confined life during pregnancy. There are no figures for the United States, but from the reports of Smith (24) of Rocky Mount and my own observations in Charlotte, I suspect that this condition is not very infrequent in North Carolina.

Balfour says that in Bombay this anæmia is more prevalent during the last half of the year because of the great number of diarrhœal cases at that time.

Of 500 cases taken from the literature (2, 7, 8, 11, 12, 14, 15, 16, 21, 22, 23, 24) 75 per cent occurred in patients under 30 years of age and 29 per cent occurred in primiparæ.

The appearance of the patient is that seen in any severe anæmia. There is a lemon tint to the skin in half the cases (22). Puffiness of the face and feet is common. The symptoms are those of any severe anæmia: weakness, vertigo, dyspnœa, palpitation, poor vision, and, especially, sore mouth, diarrhœa, and vomiting. There is generally fever (Schmidt reports fever in 97 per cent) starting a day or two after delivery and frequently leading to the mistaken diagnosis of sepsis.

The physical findings include blanched mucous membranes, retinal hæmorrhages (1, 11, 21, 22), sore tongue, a great variety of heart murmurs, enlargement of the spleen (Balfour, 18 per cent; Larrabee, 70 per cent; Schmidt, 30 per cent; McSwinney 16 per cent) and less often enlargement of the liver (Balfour 8 per cent, Larrabee 16 per cent) with slight œdema often limited to the face. Probably because of the short duration of the anæmia, cord lesions have not been demonstrated though pain and paræsthesias are common (21, 22). The blood pressure may be low as in anæmia generally or it may rise as in other toxæmias of pregnancy (21).

About one-half of the cases show a variable amount of albumin in the urine with urobilinogen and occasional casts. Hoskins has reported bile in the urine. There are no other urinary findings of interest.

The gastric juice may show diminished or absent free hydrochloric acid (21, 22), but achlorhydria is not the invariable rule here as in chronic pernicious anæmia.

The blood picture is very much like that of ordinary pernicious anæmia with greatly diminished hæmoglobin and red cells, a high color index, and the usual variation in size, shape, and staining reactions of the red cells. The diameter of the red cells is decreased (8, 15, 22) rather than increased. Nucleated red cells are present, but in the majority of cases these are normoblasts. The platelets have been reported as diminished (1, 8) or normal (15). The bile pigments in the blood are increased. Minot reports increased fragility of the red blood cells with 16 per cent reticulocytes in one case before delivery, both of these factors promptly returning to normal after delivery. There is some discrepancy of opinion about the number of white cells. Aubertin says that there are generally more than 15,000 and in 53 cases he has never seen less than 4,000; Schmidt reports 10,000 or more leucocytes in 68 per cent of cases and

[1] Read before The Association of American Physicians, Washington, D.C., May 1, 1928.

less than 6,000 in 28 per cent; Rowland says "there may be a leucocytosis regularly during the rapid hæmogenesis of convalescence, as well as in the early so-called physiologic stage of the anæmia," and cites one of Osler's (19) cases in which there were 45,000 leucocytes; other observers report leucopænia frequently as low as 2,500 (12, 24).

A tabulation of some of the cases recently reported (1, 2, 3, 6, 7, 8, 11, 12, 14, 15, 16, 19, 21, 22, 23, 24) shows an average hæmoglobin of 30.1 per cent in 101 cases and an average red cell count of 1,467,000 in 137 cases giving an average color index slightly above 1; in 55 cases the leucocytes averaged 6,746 with polynuclears 58.2 per cent, lymphocytes 36.3 per cent, large mononuclears 4 per cent, and eosinophiles 1.5 per cent.

The anæmia comes on insidiously during the later months of pregnancy and is generally discovered shortly after delivery. Miscarriage or premature labor is the rule. The loss of blood during labor is less than normal. The child fortunately does not share the mother's anæmia (1, 18). The course may be rapidly downward to death within a week or recovery may ensue after several months of illness.

After the uterus is empty, blood transfusion stops hæmolysis and leads to prompt recovery in 90 per cent of the cases (3, 8, 10, 11, 12, 13, 16, 17, 20, 21, 22, 24). I can find no record of recovery before delivery and Aubertin says recovery is unknown except after the uterus has been emptied. Rowland recommends that this measure be carried out promptly. Without transfusion 84 out of 211 patients or 40 per cent have died (2, 9, 12, 14, 15, 16, 19, 21, 23, 24, 25); Gallupe and O'Hara place the maternal mortality at 50 per cent, Larrabee at 75 per cent, and Delmen (5) at 87 per cent. McSwinney had a mortality of 35 per cent in 43 hospital patients in Calcutta and Balfour reports a mortality of 42 per cent among 150 patients seen by her in Bombay.

The changes found at autopsy as described by Schmidt and by Balfour are similar to those found in chronic pernicious anæmia. That this anæmia is due in some way to pregnancy seems obvious, but speculation as to how pregnancy produces it does not seem profitable in the present state of our knowledge. As emphasized 10 years ago by Schmidt, blood transfusion is a life-saving measure, but this fact is not as well known as it might be.

As was to be expected following the work of Minot and Murphy, the feeding of liver has been recommended in mild types of hæmolytic anæmia by Murdock (16), but in a large percentage of instances the process is too acute to warrant the institution of a dietary therapy. It may be that liver feeding after transfusion will be beneficial and it will be very interesting to see what liver feeding during pregnancy may accomplish in preventing this anæmia. However, when one of these cases is recognized, prompt transfusion is certainly the safest therapeutic measure.

CASE 1. In 1910, I saw with Dr. F. D. Austin a young primipara 3 months after normal delivery at term. She had developed diarrhœa a month or so before labor and this had continued during the 3 months since labor. Examination of the blood showed hæmoglobin 35 per cent, red count 940,000, color index 1.8, white count 6,000, with a normal differential count. There were 420 nucleated red cells per cubic millimeter. The patient recovered completely on symptomatic treatment.

CASE 2. In April, 1924, Dr. J. A. Anderson of Gastonia referred to me a young married woman, 19 years old, with a rather well marked secondary anæmia. The previous January she had had a miscarriage at the end of the seventh month, and a week later had œdema, a greenish yellow color, and went into collapse but gradually improved under symptomatic treatment. The next year she went through normal pregnancy and labor without anæmia.

CASE 3. In July, 1925, I saw with Dr. Vann Matthews a woman of 30 years, 5 weeks after her third pregnancy had terminated at term by normal labor. She had fever beginning the day after labor and at the end of 3 weeks had a greenish look. A week before I saw her, Dr. Matthews had given her a transfusion. The hæmoglobin was then 35 per cent, and there were 1,108,000 red cells and 2,400 white cells. During the week after her transfusion she had suffered from an infected arm and violent herpes labialis, so that when I saw her, the hæmoglobin was 25 per cent, red cells 832,000, color index 1.5, white count 2,700 with polynuclears 55 per cent, lymphocytes 44 per cent, and eosinophiles 1 per cent. The red cells showed considerable variation in size, shape, and staining reaction and a few normoblasts were seen. After another transfusion, this patient made an uneventful recovery and is well today.

CASE 4. In March, 1926, Dr. James Davis, of Wadesboro, brought me a young married woman of 24 years. Six weeks before she had had normal labor following a 9 months' pregnancy. During the puerperium she had fever daily and had become steadily paler and weaker, but had refused to go to the hospital until it became evident that she would die. She was seen at midnight. Temperature was 101 degrees, pulse 125, respiration 46 with marked air hunger. The patient was comatose and restless. Her skin was very pale with a strong lemon tint. There was some œdema of the face, but none elsewhere. The examination of the blood showed hæmoglobin 25 per cent, red count 742,000, color index 1.8, white count 6,600 with polynuclears 66 per cent, lymphocytes 33 per cent, basophiles 1 per cent; the red cells showed marked variation in size, shape and staining reaction and many nucleated reds were present including typical megaloblasts. The urine showed only a trace of albumin but was positive for urobilinogen. The patient was at once given a citrate transfusion by Dr. Barret and a second one the next day. At the end of 10 days she was sent home with a hæmoglobin of 50 per cent and a red count of 3,472,000.

On August 31, 1927, Dr. Barret and I were called to Wadesboro to see this patient again. Her third pregnancy had ended at term with a normal labor 19 days before. A week before delivery the hæmoglobin had been 50 per cent and the red count 2,500,000. The day before delivery, her blood pressure reached 160. Urine showed albumin and casts in abundance. For 2 weeks after delivery she was apparently holding her own but then developed an abscessed breast. The hæmoglobin dropped to 30 per cent and the red cells to 1,292,000. The color index was 1.1. She had had fever ever since delivery. When the patient was seen on August 31, the hæmoglobin was 10 per cent and the red count was 960,000 with great variation of size, shape, and staining reaction of the red cells. Many normoblasts were seen but no megaloblasts. The white count was only 2,500 with 70 per cent polynuclears. She was given 800 cubic centimeters of blood by direct transfusion by Dr. Barret. On September 28 Dr. Davis reported that the hæmoglobin was 65 per cent, the red blood cell count 2,800,000, and the white cell count 5,000. The patient was steadily improving.

There have been some reports of the recurrence of this anæmia in subsequent pregnancies. Murdock thinks there is a strong probability of recurrence and thought it likely that his second patient had suffered with hæmolytic anæmia following labor 6 years previously. In the second case reported by Gallupe and O'Hara there was a history of anæmia in each of the 3 preceding pregnancies severe enough in the next preceding pregnancy to have kept the patient in bed for a few weeks.

Halir (9) reports the case of a woman, age 21 years, who presented a picture of pernicious anæmia in 1920, 8 weeks after delivery. In the spring of 1923, she returned, 3 months' pregnant, and again presented a picture of pernicious anæmia. She died the next year with Hodgkin's disease.

Oettingen (17) reports the case of a woman with hæmolytic anæmia following her third pregnancy, who had had severe anæmia of some sort with her first pregnancies. To prevent recurrence she was sterilized. Reist (20) reports the case of a woman who had been chlorotic from her fifteenth to nineteenth years. She was anæmic during the first and second pregnancies and after her third pregnancy presented a picture of pernicious anæmia. She was sterilized to prevent further recurrence.

Vermelin and Vigneul (25) report the case of a woman whose first pregnancy was normal; in the fifth month of her second pregnancy she showed pernicious anæmia and miscarried during the eighth month with fetus stillborn. She was clinically normal the next year, but aborted during the second month of her third pregnancy. Three months later she again became pregnant and in the seventh month of this fourth pregnancy showed the picture of pernicious anæmia. Premature delivery was induced. The patient died 2 days later.

McSwinney saw a woman during her sixth pregnancy with hæmoglobin 40 per cent, white blood count 3,000,000, color index .66. A year later at the time of her seventh labor the hæmoglobin was 35 per cent, with red count 2,000,000, color index .88. The patient grew rapidly worse and died 5 days after labor.

These reports on recurrence show that the patient seen in two succeeding pregnancies by Halir died a year later of Hodgkin's disease. The patient seen in two succeeding pregnancies by McSwinney died within a week after the second labor. The others all saw women who gave a clinical history of anæmia with previous pregnancies. The fourth case reported was seen in two succeeding preg-

nancies, each time with less than 1,000,000 red cells, and in each incidence recovered promptly after transfusion.

Because of the rarity of recurrence and the promptness with which this anæmia can be controlled by transfusion, sterilization of these patients to prevent possible recurrence seems to me entirely unwarranted.

SUMMARY

The hæmolytic anæmia of pregnancy is an acute condition and should no longer be classified as pernicious anæmia.

It responds promptly to blood transfusion after the uterus has been emptied.

The danger of recurrence need not be a contra-indication to pregnancy and calls for nothing more radical than proper supervision of the patient during subsequent pregnancies.

BIBLIOGRAPHY

1. Aubertin, C. Presse méd., 1924, xxxii, 13.
2. Balfour, M. I. Indian M. Gaz., 1927, lxii, 491.
3. Bonta, M. B. Rep. Weekly Staff Meeting Mayo Clinic, 1926, i, 53.
4. Cabot, R. C. Osler's Modern Medicine, 1927, v, 35.
5. Delmen. Thes. de doct., Paris, 1913. Quoted by Schmidt.
6. Drexel, T. Med. Klin., 1926, xxii, 961.
7. Findley, P. Am. J. Obst., 1918, lxxviii, 262.
8. Gallupe, H. Q., and O'Hara, D. Boston M. & S. J., 1924, cxc, 161.
9. Halir, O. Med. Klin., 1925, xxi, 498.
10. Heim, K. Zentralbl. f. Gynaek., 1923, xlvii, 818.
11. Hoskins, T. J. Lancet, 1927, ccxii, 433.
12. Larrabee, R. C. Am. J. M. Sc., 1925, clxx, 371.
13. Levy-Solal and Tzanck, A. T. Presse méd., 1927, xxxv, 1505.
14. McSwinney, S. A. Indian M. Gaz., 1927, lxii, 487.
15. Minot, R. G. Med. Clin. N. Am., 1921, iv, 1733.
16. Murdock, T. P. Ann. Int. Med., 1927, i, 133.
17. Oettingen, V. Zentralbl. f. Gynaek., 1924, xlviii, 1506.
18. Offergeld, H. Monatschr. f. Geburtsh. u. Gynaek., 1926, lxxiv, 245.
19. Osler, W. Brit. M. J., 1919, i, 1.
20. Reist, A. Zentralbl. f. Gynaek., 1926, l, 1496.
21. Rowland, V. C. J. Am. M. Ass., 1924, lxxxii, 375.
22. Schmidt, H. B. Surg., Gynec. & Obst., 1918, xxvii, 596.
23. Schneider, G. H. Monatschr. f. Geburtsh. u. Gynaek., 1924, lxv, 321.
24. Smith, C. T. Surg., Gynec. & Obst., 1925, xl, 223.
25. Vermelin and Vigneul. Quoted by Reist.

CLINICAL SURGERY

FROM THE BRONCHOSCOPIC CLINIC OF THE ROYAL VICTORIA HOSPITAL

THE TECHNIQUE OF BRONCHOSCOPIC PNEUMONOGRAPHY WITH LIPIODOL

By DAVID H. BALLON, M.D., F.A.C.S., Montreal, Canada

SINCE the epoch-making introduction of lipiodol in 1922 by Sicard and Forestier (13) in the diagnosis of bronchopulmonary lesions, numerous methods have been devised for the injection of lipiodol in the bronchial tree. These methods can be classified into two groups: the direct bronchoscopic (2 and 3) and the indirect intratracheal methods.

Our purpose here is not to discuss the merits, difficulties, and dangers of the different intratracheal methods—they all have their place and importance—but rather to emphasize the value of the direct bronchoscopic method for pneumonography (5) for the following reasons:

1. The invaluable aid afforded by direct inspection of the bronchial tree.

2. The possibility of making a bronchoscopic diagnosis; taking uncontaminated cultures for diagnosis and vaccine therapy; removing stenosing granulations (4) and aspirating pus from drowned areas of the lung, and thus allowing a more thorough filling of the region of the lung to be investigated.

3. If lipiodol has any therapeutic value then it is most desirable that before it is introduced, bronchi and cavities filled with pus and débris should first be cleared as thoroughly as possible in order that this iodized oil can act directly on diseased mucous membrane, and its effect be observed at a later date.

4. As our knowledge of the interpretation of lipiodol roentgenograms is still very imperfect and in order to avoid grave diagnostic errors, the bronchoscopic method remains essential for the elucidation of roentgenograms and the clinical findings.

INDICATIONS

Every case for pneumonography must be considered by itself and a decision arrived at by the internist, surgeon, roentgenologist, and bronchoscopist, before the injection is carried out. As a general rule, the cases suitable for injection are all forms of chronic bronchopulmonary and pleural suppurations in which a differential diagnosis between bronchiectasis (6), lung abscess, bronchopleural fistula, and empyema is required; also a more accurate differentiation between upper and lower lobe lesions. Lipiodol may be used in cases of acute lung abscess (9) in which other methods have failed to demonstrate a lesion. It is particularly valuable in lesions of the left lung masked by cardiac shadow and pleural thickening.

Lipiodol can be used with comparative safety in carefully selected cases of the surgical type of pulmonary tuberculosis which show definite evidence of resistance. After extrapleural thoracoplasty, lipiodol injections will demonstrate the efficiency of collapse and reveal the cause for persistent signs and symptoms.

CONTRA-INDICATIONS

In pulmonary tuberculosis (7) of the exudative type, lipiodol not only produces an immediate reaction but may reactivate a quiescent lesion, and its persistence in the lung may be attended with ill effects. These observations have been noted both clinically and experimentally. As a general rule patients with advanced bronchopulmonary diseases, and recent hæmoptysis, should not be injected.

DANGERS

Bronchoscopy in the hands of a gentle, careful, thoroughly trained bronchoscopist is practically devoid of danger (1). This has been frequently emphasized by Chevalier Jackson (12) and borne out by the large number of cases examined in his clinic.

To obtain a pneumonogram of real diagnostic value requires proper anæsthesia; it is extremely difficult to carry out a satisfactory bronchoscopic examination and lipiodol injection without any cocaine anæsthesia, in patients who cough in-

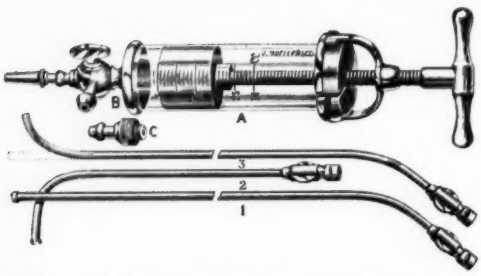

Fig. 1. Ballon lipiodol injecting equipment. The syringe, *A*, is of the 30 cubic centimeters Record type, with metal plunger and glass barrel ground to fit smoothly. A threaded plunger rod with a bar-type handle provides a slow, powerful plunger action which easily injects the heaviest of solutions. The injection tubes, *1*, *2*, and *3*, are attached by means of a regular bayonet lock arrangement. Tube *1* is made in three lengths—39, 47, and 53 centimeters. Tube *2* is for indirect injection. Lynah's tube, *3*, is used for injecting into the upper lobe of the lung.

cessantly. This drug, used after a preliminary hypodermic injection of morphia and atropin, is of great value in effectively allaying irritating cough temporarily. Otherwise, in imperfectly prepared patients, iodized oil scarcely reaches the site of the disease before it is expelled by the active cough reflexes.

But the actual vital danger and the powerful toxic action of cocaine must ever be kept uppermost in mind. It must be used very cautiously. Unfortunately until now we have not found any anæsthetic which, by local application, has the value and effect of cocaine.

Although at least 50 per cent of the patients swallow some lipiodol, as shown by the roentgen ray, no signs of iodism have been found in any of my patients. A patient of Dr. Archibald, with an idiosyncrasy to iodine, who developed toxic symptoms on two occasions when iodine was applied to the chest wall, and on another when iodine ointment was painted on the skin, showed no ill effects when lipiodol was injected subcutaneously, and when at a later date it was given by mouth. This patient was subsequently injected bronchoscopically with 17 cubic centimeters of lipiodol without showing any signs of iodism.

Lipiodol may be injected with safety in chronic pulmonary suppuration. It is extremely dangerous, however, to inject lipiodol or any other foreign liquid in the lung when there is an associated acute respiratory infection, or an acute exacerbation of the chronic suppurative process. In these cases the ill effects produced by lipiodol were the result of an aggravation of the underlying condition, or a direct extension of the lesion.

In experimentally produced pulmonary tuberculosis in rabbits, Harry Ballon (10) found that the injection of lipiodol in these animals, especially when there was an associated acute pneumonic process, was immediately followed by grave symptoms and ended fatally. In pulmonary tuberculosis, a quiescent lesion may be reactivated by iodized oil. Iglauer (11) noted the appearance of tubercle bacilli in the sputum for the first time following the injection of iodized oil.

One of the late dangers which will have to be seriously considered is the confusion in diagnosis caused by persistent lipiodol shadows, and roentgenologists will have to be on guard in the interpretation of these roentgen-ray shadows. The presence of lipiodol in the alveoli may resemble an unresolved pneumonia, or an exudative or miliary tuberculosis (7).

PREPARATION OF THE PATIENT

Every patient to be injected with lipiodol should have a preliminary physical and roentgen-ray examination. All patients whether ambulatory or bedridden are examined early in the morning on an *empty stomach* to avoid retching and vomiting.

Morphia is valuable as a sedative for the irritating cough, and atropin checks the profuse salivation. Adults receive a hypodermic injection of ¼ grain of morphia and 1–150 or 1–100 grain of atropin, one hour before the local anæsthetic is applied. Patients with extremely irritable throats, who cough incessantly and bring up enormous quantities of pus, are given another ⅛ grain of morphia hypodermically at the beginning of the local anæsthetic. Pantopon is substituted for morphia when the latter is not tolerated. In children between the ages of 10 and 15 years, graded doses of morphia are to be used. The preliminary hypodermic may be dispensed with in some patients who have previously been bronchoscoped.

ANÆSTHETIZATION

All injections in my bronchoscopic series of 125 patients, ranging between the ages of 11 and 65 years, were carried out under local anæsthesia (8). It is essential to anæsthetize thoroughly the pharynx, hypopharynx, and larynx. For this purpose the following mixture is used: 20 per cent solution of cocaine hydrochloride, 1 part; 1:1000 solution of adrenalin chloride, 2 parts.

In some patients it is of advantage to inject into the trachea with a laryngeal syringe, one-half of 1 cubic centimeter of a mixture of equal

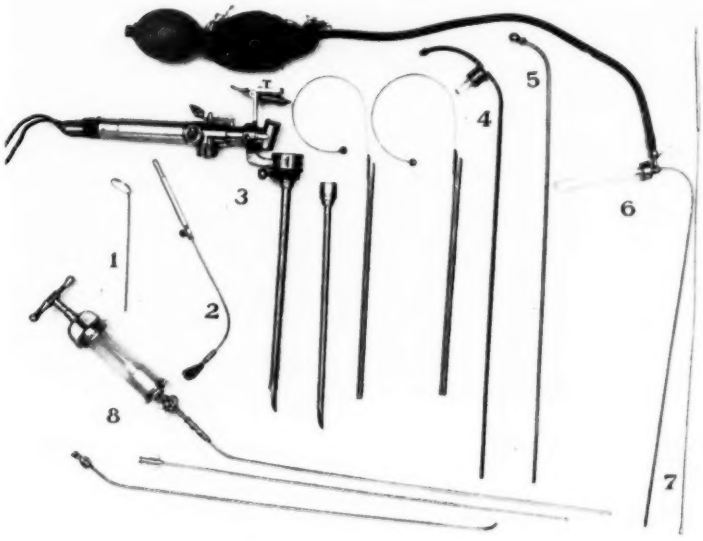

Fig. 2. Instruments required for bronchoscopic pneumonography. Laryngeal mirror, *1*, and camel's hair brush, *2*, for cocainization. Kahler-Leiter bronchoscope, *3*, with No. 10 and No. 8½ tubes for adults and children. Clerf's glass specimen collector, *4*. Aspirating tube to be attached to portable aspirator, *5*. Cocaine-adrenalin spray if required, *6*. Applicator, *7*. Ballon's lipiodol injecting syringe with tube attached, *8*.

parts of 5 per cent cocaine with 1:1000 adrenalin chloride solution, prior to the passing of the bronchoscope. This weaker cocaine solution is also sprayed into the trachea and bronchi after the bronchoscope is passed; the spraying is done by a nurse or assistant. Topical applications of this mixture to the carina and bronchi are safer than spraying and, therefore, preferable.

INSTRUMENTS

The following instruments are required: (1) For the preliminary cocainization: a laryngeal mirror and a laryngeal applicator or camel's hair brush. (2) For the bronchoscopic examination: a bronchoscope—Jackson, Kahler-Leiter, or Bruning; a portable aspirator with aspirating tubes; sponge carriers for gauze sponges; a Clerf's glass specimen collector; and a cocaine spray. (3) For the pneumonography: Ballon's lipiodol syringe with tubes, or any other suitable syringe.

Any standard bronchoscope may be used for pneumonography depending largely on the experience of the examiner with a certain instrument. The author has used for this purpose the Kahler-Leiter bronchoscope. Two tubes are required, No. 8.5 for children, and No. 10 for adults.

DOSAGE

The quantity of lipiodol to be injected varies from 10 to 40 cubic centimeters and is determined by the age, size, condition of the patient, the nature and extent of the lesion, and the normal lung area requiring to be filled for contrast. In order to map out both lungs, 25 to 30 cubic centimeters is usually sufficient.

TECHNIQUE

After the preliminary cocainization, a roentgenogram is taken; the patient is then placed on the roentgen-ray examining table in the dorsal decubitus position. The usual aseptic precautions are observed. The head is slightly elevated and extended, and rests on the table; the eyes and face remain uncovered; the teeth are protected by a layer of gauze; the bronchoscope, warmed over an alcohol flame, is held in the right hand and supported by the fingers of the left hand—the latter also protects the upper teeth and lip—then gently passed between the anæsthetized cords into the trachea. A culture is taken with a Clerf's glass specimen collector; the local anæsthetic is then sprayed or applied to the trachea, the main carina, and bronchi, to obtund the cough; pus and secretion are aspirated from the

Fig. 3. Position of patient for introduction of bronchoscope. The patient's head is slightly raised and extended, and rests on the table.

trachea and main bronchi in order to permit of a better filling. A careful examination is now made of the area of the lung to be injected, granulations, if present, are removed for biopsy, and lipiodol is then injected with any suitable syringe through the bronchoscope into the different bronchi under direct vision, the nurse or assistant slowly turning the piston of the syringe. While the patient is being injected, he can be

Fig. 4. Position of the patient, operator, and nurse during the bronchoscopic injection of lipiodol. The assisting nurse and the instrument table are to the right of the bronchoscopist. The Kahler-Kleiter bronchoscope is passed with the right hand into the right bronchus, the lipiodol tube is then passed under direct vision through the bronchoscope into the same bronchus, and the assistant slowly turns the screw of the lipiodol syringe. The only assistance required with this technique is one nurse.

Fig. 5. Roentgenogram showing bronchoscope in trachea, the lipiodol injecting tube in the right lower bronchus and 5 cubic centimeters of lipiodol in the bronchi.

turned either to the right or to the left side and so both halves of the lung are filled, as with the patient in the dorsal decubitus the posterior part of the lung is chiefly outlined. Fluoroscopic observations can also be made at this time; this often affords an excellent means of localizing the lesion. As soon as the injection is completed the bronchoscope is withdrawn, the patient being cautioned not to cough, and roentgenograms taken in the supine, prone, semilateral, lateral, and sitting positions, as the case may indicate. When the patient has been thoroughly anæsthetized, a series of roentgenograms can be taken; in one instance a dozen were taken at intervals of 4 minutes, and studies made of the effect of posture, respiratory movements, and the cough reflex. Anteroposterior views are taken with the head raised 45 degrees in order to permit the better filling of the lower lobes. The head is later lowered 45 degrees in order to observe whether the upper lobes would be better filled by change of posture. Stereoscopic pictures should always be taken immediately after the injection has been completed, with the patient in the dorsal decubitus or sitting position.

The advantage of the author's bronchoscopic method is that the entire technique is carried out by the operator with the sole assistance of a nurse trained in bronchoscopy, who hands instruments, suction tube, sponges, and turns the piston of the lipiodol syringe.

In pulmonary tuberculosis only the diseased area is to be injected and the quantity limited to 10 to 15 cubic centimeters. In cases of pulmonary tuberculosis where the bronchoscopic examina-

tion may be contra-indicated the lipiodol can be injected by the transglottic method.

The after-care is confined to symptomatic treatment.

BIBLIOGRAPHY

1. Archibald, Edward, and Brown, A. Lincoln. Dangers of introducing iodized oil into the tracheobronchial system. J. Am. M. Ass., 1927, lxxviii, 1310–1315.
2. Ballon, David H. The injection of lipiodol as an aid in the X-ray diagnosis of bronchopulmonary lesions, including tuberculosis. Canad. M. Ass. J., 1925, xv, 995–999.
3. Idem. Lipiodol in the diagnosis of bronchopulmonary lesions by the bronchoscopic method; report of fifty cases. Arch. Otol., 1926, iii, 403–422.
4. Idem. Primary carcinoma of the bronchus with abscess of the lung diagnosed bronchoscopically and injected with lipiodol. N. York M. J. & Rec., 1927, cxxv, 225–228.
5. Ballon, David H., and Ballon, Harry C. Pneumonography with iodized oil, 40 per cent, by the bronchoscopic method. Arch. Surg., 1927, xiv, 184–202.
6. Idem. The diagnosis of bronchiectasis. Further studies on the value of lipiodol by the bronchoscopic method. Acta Oto-Laryngol., 1927, xi.
7. Idem. The effect of injection of lipiodol and the rate of its disappearance in the normal and diseased lungs. Canad. M. Ass. J., 1927, xvii, 410–416.
8. Idem. Einige Beobachtungen ueber den Wert des Lipiodols als Hilfsmittel in der Diagnose und als Wegweiser in der Behandlung von Krankheiten des Bronchopulmonaltraktes. Monatschr. f. Ohrenh. u. Laryngo-Rhinol., 1927, lxi, 1197–1234.
9. Ballon, Harry C. The value of lipiodol in the diagnosis and treatment of abscess of the lung. Surg., Gynec. & Obst., 1927, lxiv, 1–10.
10. Idem. Lipiodol bei Lungentuberkulose; experimentelle klinische und pathologische Studie. Frankfurt. Ztschr. f. Path., 1928, xxxvi, 207–221.
11. Iglauer, Samuel. The use of iodized oil in the diagnosis of pulmonary lesions. Surg., Gynec. & Obst., 1927, xlv, 82–87.
12. Jackson, Chevalier. Bronchoscopy and œsophagoscopy; a brief consideration of technique. Surg., Gynec. & Obst., 1927, xliv, 795–804.
13. Sicard, J. A., and Forestier, G. Méthode générale d'exploration radiologique par l'huile iodée. Bull. et mém. Soc. méd. d. hôp. de Par., 1922, xlvi, 463.

FROM THE PEKING UNION MEDICAL COLLEGE

ASEPTIC INTESTINAL ANASTOMOSIS IN RESECTIONS OF THE LARGE BOWEL[1]

By J. R. B. BRANCH, M.D., F.A.C.S., Peking, China

FOR many years surgeons have striven toward the goal of aseptic intestinal anastomosis. Much experimental work has been done and numerous articles have been published on the subject. I should like to call attention to the excellent clinical results attending the use at the Peking Union Medical College of the method described by Scarff.[2] While it may be true from a theoretical point of view that "aseptic" intestinal anastomosis is impossible, it is equally true that the Scarff method reduces the chances of infection to a minimum. The operation is simple, is easily and quickly performed, and requires no special instruments. The results so far are good. After trying Scarff's technique on dogs, I have used it clinically where end-to-end anastomosis of the small bowel was indicated. Since then, having had several resections of the cæcum and ascending colon to do for intestinal tuberculosis, I have adapted the operation to end-to-side anastomosis. In some cases the terminal ileum has hypertrophied to overcome the cæcal obstruction and is as large as the transverse colon. In two of our recent cases this was so, and an end-to-end anastomosis was done. These patients have without exception done quite satisfactorily, so satisfactorily that it seems worth while describing our variation of the Scarff method and publishing the accompanying illustrations.

The bowel is freed from its mesenteric attachments, beginning, of course, with the lateral avascular peritoneal reflection. Ordinary straight, serrated clamps, the jaws of which have been lubricated with liquid paraffin, are used to crush the bowel before excision. The cautery is to be preferred for the excision, because it seals as well as sterilizes the crushed intestinal surfaces.

The divided end of the colon is closed with purse-string suture of catgut, re-enforced with silk, inverting the sealed stump. The lateral wall is caught in the jaws of a straight clamp for a length equal to the diameter of the terminal ileum. The narrow strip protruding through the jaws of the clamp is burned away with the cautery. This may be done either in the longitudinal or transverse axis of the colon. Mattress sutures of black silk are now placed as shown in the illustration. When the clamps are carefully withdrawn, the two narrow, crushed, sealed, parchment-like strips come together as the sutures are tightened and tied. This line is re-enforced by another row of Lembert sutures of fine silk. Traction upon opposite sutures opens up the stoma. The mesentery is now approximated with interrupted silk sutures.

I have invariably performed a prophylactic, or as it is sometimes called, a complementary, enterostomy by inserting a small rubber catheter into the ileum proximal to the anastomosis, after the manner of Witzel, and bringing it out through a stab wound in the lateral abdominal wall. If possible, the anastomosis and site of the enterostomy are covered by omentum. This life-saving and worry-dispelling suggestion of Mayo has proved invaluable in cases in which the surgeon anticipates distention or paralytic ileus.

Nothing is allowed by mouth or rectum for at least 4 days, 5 are better. Fluids (usually 1,000 to 2,000 cubic centimeters of 2.5 per cent glucose) are given daily subcutaneously or intravenously. I am convinced that this rest to the intestinal tract is well worth the discomfort it causes, though to insure co-operation the patient must be prepared for it. The enterostomy tube can be removed in from 7 to 15 days and the sinus closes spontaneously before the patient leaves the hospital, usually in a week. In all of our cases, convalescence has been uninterrupted; not even in a case complicated by tuberculous peritonitis was there persistence of the fæcal fistula.

[2] Scarff. Aseptic end-to-end suture of intestine. Ann. Surg., April, 1926, 490.

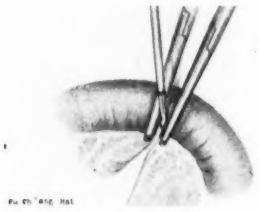

Fig. 1. Dividing the clamped bowel with the cautery. The clamps should not extend on to the mesentery.

I should like to express my gratitude to our artist, Mr Pu Chang Hai, for the drawings illustrating this paper.

[1] From the Surgical Department of the Peking Union Medical College, Peking, China.

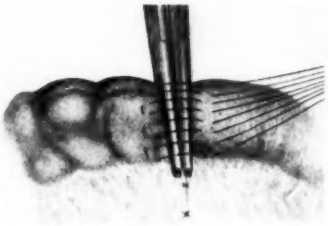

Fig. 2.

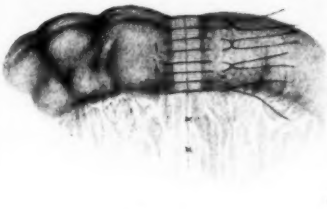

Fig. 3.

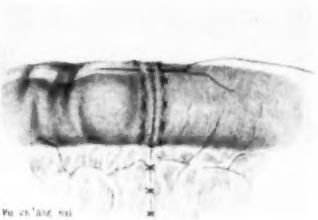

Fig. 4.

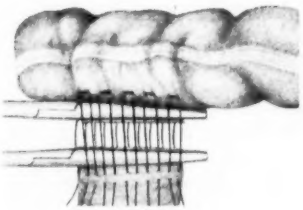

Fig. 5.

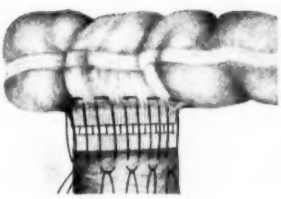

Fig. 6.

Fig. 7.

Fig. 2. The diseased portion of bowel has been removed. The clamps are approximating the ends which have been cut and sealed with the cautery. Mattress sutures of silk have been inserted, in practice much nearer to the clamps than indicated in the illustration.

Fig. 3. Clamps have been removed, showing the bowel ends crushed and sealed.

Fig. 4. First row of sutures tied, the ends turned in, and one of the second row of sutures introduced. These sutures, for the purpose of illustration, are drawn farther apart than they are actually inserted.

Fig. 5. End-to-side anastomosis. The lateral wall of the colon has been clamped and the portion which bulges through it has been burned away. The ileum is brought into contact with it and mattress sutures are being introduced.

Fig. 6. The clamps have been removed, bringing into view the crushed side of the cæcum and the end of the ileum.

Fig. 7. Mattress sutures tied and one of the Lembert row being introduced. This completes the anastomosis. (The ileum is drawn much too large.)

EPISPADIAS IN FEMALES AND ITS SURGICAL TREATMENT[1]

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IT is commonly stated in textbooks and elsewhere that, in the female, epispadias is a very rare condition, a curiosity for the surgeon, which he must meet by genial improvisation, if he be capable thereof. Study of the literature, however, discloses that quite a large number of cases has been reported, for the most part singly, and that while surgical improvisation has been depended upon in the treatment of most of them, it is now possible, as a result of all this experience, to formulate definite and well founded surgical principles which should govern the operations performed for this condition.

The analogy between epispadias in the female and epispadias in the male was first recognized by Morpain in 1855 (48). He observed a case in a female, 61 years of age, described it accurately, and published an excellent drawing of it. Similar cases had previously been observed but no one had seriously attempted an explanation of the condition or given it a name. This bit of keen observation and accurate reasoning by Morpain deserves to be noted. His conclusions, however, were doubted and even opposed by many. Most surgical writers of his day, and for some time thereafter denied the existence of epispadias in the female. Among these was Guyon, but later on, when he had the opportunity of observing a case, he admitted his error. This case of Guyon was reported by Nunez in 1882 (52). He also discussed most of the cases which had been observed up to that time. The classic monograph is that of Durand in 1895 (17). Durand had no case of his own and his search of the literature was incomplete since he referred to only 9 cases. However, from these cases he constructed a theory of the embryological origin and a classification of the cases into three groups. This classification has been generally accepted up to the present time. In 1896 Ballantyne (7) published another monograph including a study of 33 cases which he had found in a very thorough search of the literature. He follows the classification of Durand and expresses rather pessimistic views concerning the advisability of surgical treatment. Rasch in 1897 (62) wrote a splendid summary of the subject up to that date. He also follows Durand and goes much more thoroughly into the surgical possibilities. His conclusions, however, are somewhat indefinite and leave the operator a wide choice. Other excellent articles were published by Nové-Josserand and Cotte (51) and Burckhardt (11).

Ideas which have been held concerning the embryological origin of epispadias in the male are well known to most urologists, and the explanation of the condition in the female is undoubtedly the same. Numerous theories have been advanced and discarded. Among them may be mentioned that which holds that epispadias, hypospadias, exstrophy, etc., are due to rupture of the lower urinary tract following temporary occlusion of the urethra (10); that an inflammatory or some other pathological lesion of the lower abdominal wall and cloacal tubercle are responsible; that a rotation of the penis causes the urethra to lie above the corpora cavernosa (29); that there is a retardation in the fusion of the cavernous bodies, permitting the urethra to pass upward between them; and that epispadias is due to a retardation in the development of the cloacal tubercle (78).

At present our views, as stated by Johnson (33) "are based upon a purely embryological defect, and the same explanation is given for both exstrophy of the bladder and epispadias, the difference being merely one of degree." There is "a cephalad displacement of the cloacal membrane in an early stage of development before the cloacal tubercle has made its appearance. The cloacal tubercle developing later arises below the cloacal membrane so that when the membrane is resorbed the urogenital sinus opens on the dorsum of the phallus rather than on the ventrum. If the displacement of the cloacal membrane extends on to the primitive abdominal wall, the result will be exstrophy of the bladder; if the displacement is of lesser degree, epispadias alone results." According to this theory, one should find cases showing all degrees of the deformity from complete exstrophy of the bladder on the one hand, to a slight upward displacement of the urethral orifice on the other. These gradations do exist in the female as in the male and lend support to this hypothesis.

MORPHOLOGY

The majority of cases, however, correspond to quite a definite type and a short description of this type may be given at this point. In the female the two halves, or corpora cavernosa, of the cloacal tubercle do not unite beneath the dis-

[1] From the Surgical Clinic, Strong Memorial Hospital, Rochester, New York.

placed urethra as they do in the male, at any rate no such case has been found described in the literature, unless it be that of Coustou (13), who simply states that "the urethra opened above the clitoris." Instead the two halves of the clitoris, which may be markedly underdeveloped, remain separated by a considerable distance, amounting to several centimeters in adult patients. Along with this separation, the anterior portions of the labia minora and labia majora also fail to unite, so that a depressed area is left over the site usually occupied by the mons veneris. This depressed area is covered by a smooth, glabrous, hairless skin, beneath which there may be a moderate amount of subcutaneous tissue and fat or the skin may be very closely applied to the anterior and inferior surfaces of the symphysis pubis. The labia minora are usually ill-developed and terminate anteriorly at the corresponding half of the bifid clitoris where there may be a rudiment of the preputial fold. These external appearances are most characteristic. On separating the labia, however, one sees the urethra which may vary considerably in appearance. It may open between the two haves of the clitoris or some distance above them, even anterior to the symphysis pubis, or it may be represented by a wide funnel-shaped opening, sometimes large enough to fill the entire space between the two halves of the clitoris and the symphysis.

The urethra is usually increased in diameter, but this increase may vary between wide limits. On probing the urethra with instrument or finger, one may find the internal sphincter intact, in which case there is no incontinence; the sphincter may be present but incompetent; or there may be no sign whatever of it, in which case it is usually possible to insert the finger directly into the bladder without resistance. Unless the internal sphincter be present and competent, there is incontinence of urine. In a number of cases, the enlargement of the urethra has been so pronounced that there is a herniation of the posterior wall of the bladder through the urethra, either continually or upon coughing, straining, or merely standing erect. The bladder capacity is usually reduced as a result of habitual incontinence, but the bladder is usually well formed and capable of dilating to its normal size. The symphysis pubis is usually closed. Early writers laid much stress on the state of the symphysis since they felt that if it were closed there could be no question of bladder exstrophy, while if it were open the condition present ought probably to be explained as a mild grade of exstrophy. It now appears that this distinction is of minor importance. A study of Table I will show that in many cases the most extreme deformity of the urethra and aplasia of the sphincteric apparatus may occur in individuals without symphyseal defect, while in the case of Sexton (70) a moderate degree of deformity, with well developed sphincter and excellent urinary control, was associated with a widely separated symphysis. This point is also illustrated by cases known as superior fissure of the bladder, which might be described as an exstrophy of the bladder which is necessarily incomplete owing to the presence of the symphysis pubis. The opening, therefore, is confined to the abdominal wall above the symphysis. In the same way a tendency to deformity of the type of epispadias in the urethra and lower part of the bladder may be influenced by the presence or absence of a closed symphysis, but it is obvious that it is not absolutely dependent thereon. The vagina and internal genitalia are usually normal, though in Nové-Josserand's case there was a double vagina. The hymen is usually circular. The rectal sphincter is usually normal. Although in some cases a prolapse has been noted, in many of these cases surgical treatment of the deformity, by doing away with the pain and straining consequent upon irritation of the parts by decomposed urine, has caused the prolapse to disappear.

INCONTINENCE

Incontinence of urine is the rule and is usually complete or nearly so. The principal exception to this rule is in those cases in which the deformity is of the first degree—the vestibular epispadias of Durand. If the internal sphincter is unaffected and normal, urinary control is present. In a few cases control is almost, but not quite, normal, there being a slight frequency, slight urgency, perhaps even slight leakage on unusual straining or exercise. The case of Sexton represents this. With those suffering with a greater degree of incontinence, it is particularly to be noted that some of them have been able to control the urine to a certain extent while lying in bed, with complete incontinence while sitting, standing, or walking. In other cases incontinence is complete in the lying position, while if the patient sits or stands, the urine may be retained for a short time. In a considerable proportion of these latter cases it has been noted that there is herniation or prolapse of the posterior bladder wall while the patient is standing. The author feels that the first group of patients represents those in whom a rudiment of sphincter is present, which is able to withhold the urine when the intra-abdominal pressure is reduced as much as possible, but not

TABLE I.

	Author	Age	Description	Incontinence	Surgical treatment	Result
1.	Arnaud. Case seen in 1761 (4)	12 yr.	2 clitorides present, "otherwise normal." Autopsy case.	Not stated	Not stated	—
2.	Petit, J. L., 1774 (54)	4 yr.	"No labia minora or clitoris."	Complete	None	—
3.	Idem	?	"External genitalia well formed; bladder opened by a hole admitting little finger easily."	Complete	None	—
4.	Penchiennati,* 1784–85 (53)	4 da.	Egg size tumor over pubic bones, covered with "common teguments," tit with orifice at upper border, discharging urine (urachus?), another orifice at lower border, discharging urine (urethra?) symphysis cleft, vagina normal.	Partial	None	Died at age of 4, badly reported autopsy.
5.	Malgaigne, 1849 (41)	Adult	Urethra opened up in front of symphysis, curved around it below, symphysis closed.	None	None	—
6.	Gosselin, 1859 (26)	Young adult	Orifice 1 cm. in diameter below pubis, slight hernia of bladder, no sphincter demonstrated, clitoris divided. Symphysis closed but loose.	None, but urgent voiding every 2 hr	None	—
7.	Testelin,* 1854 (73)	14 yr.	Anterior commissure absent, gutter over pubis, large pouting orifice above clitoris, which is single, but attached to only one labium minus, normal urethra below clitoris, lower urethra 6 cm. long, upper 4 cm. long, meet in bladder.	Complete through upper urethra only	Cauterization of upper urethra, secondary suture.	Complete closure of upper urethra, lower urethra continent, no leakage, but frequency every 45 min., 6 wk. postoperative.
8.	Henle,* 1855 (31)	17 yr.	Typical, "polyp of urethra," which was probably slight hernia of bladder.	Complete	None	—
9.	Morpain,* 1855 (48)	61 yr.	Large urethral opening just above bifid clitoris. Patient married, 2 children.	None	None	—
10.	Roeser,* 1860. Quoted by Gurlt* (66)	19 yr.	Bladder admits finger, no sphincter demonstrated, clitoris bifid, symphysis closed.	Complete	External plastic, not reaching sphincter. Later applications of silver nitrate.	Continent 1 hour, leakage on coughing and at night. Further improvement after cauterization.
11.	Moeller,* 1864 (46)	3 da.	Symphysis separated, anterior wall of bladder closed, typical epispadias, hernia of anterior abdominal wall. Autopsy case.	Not stated	None	—
12.	Surmay,* 1866 (72)	14 yr.	Typical. Bladder hernia like "half a cherry," labia minora rudimentary, bladder admits finger, with gush of urine if eversion is pushed in. Rectal prolapse with incontinence, ring hymen.	Present, worse lying than standing.	None	—
13.	Kleinwaechter,* 1869 (35)	15 yr.	Bladder admits finger, orifice 15 by 6 mm., slight herniation, clitoris bifid.	Complete	None	—
14.	Funk,* 1870 (22)	17 yr.	Urethra admits finger, menstruation normal.	Partial, leakage on exertion.	None	—
15.	Emmet,* 1872–73 (18)	12 yr.	Cleft of symphysis, defect of portion of urethra.	Could hold urine only 15 min.	Lengthening of urethra proposed, no report.	No report
16.	Savastitskii, 1873–75 (68)	?	No description given; said by Ballantyne to be a case of female epispadias.	?	?	?
17.	Coustou,* 1875 (13)	43 yr.	Urethra opened above clitoris.	None	None	—
18.	Pippingskold,* 1876 (57)	13 yr.	Large urethra, prolapse of bladder, clitoris bifid.	Partial, worse at night. Continent 1–1½ hr. during day.	2 operations, no description.	No improvement

19.	Moericke,* 1880 (47)	22 yr.	Bladder admits finger, anterior wall close to symphysis, clitoris bifid, other features typical.	Complete	(1) Unsuccessful operation at 7 yr. (2, 3, 4) Unsuccessful external plastics. (5) Resection of urethra deep into bladder, suture, urethra lengthened and kinked up over symphysis. (6, 7, 8) Poor healing, more sutures applied.	Continent 4 hr. day and night, but has urgency and leaks few drops on coughing or straining 2 mo. postoperative.
20.	Frommel,* 1882 (21)	26 yr.	Typical case, rudiment of sphincter demonstrated. Patient pregnant, followed by prolapsus uteri.	Complete	Plastic on urethra, apparently a rather deep resection, with lengthening and bending of urethra.	Continent 4 hr., no leakage. Postoperative period not stated.
21.	Nunez,* 1882 (52)	27 yr.	Large orifice into bladder, admits finger, hernia of bladder, clitoris not found, symphysis closed.	Complete	Radial cauterization of urethra.	No improvement.
22.	Campbell,* 1883 (12)	2 yr.	Large orifice into bladder, admits finger, hernia of bladder which became strangulated, reduced with difficulty. Anterior commissure absent, clitoris bifid, symphysis closed.	Complete	Operation deferred until after puberty, no further report.	—
23.	Gottschalk, 1883 (27)	1¾ yr.	Typical case, clitoris bifid, symphysis closed.	Complete	Two operations, apparently external plastics only.	Continent 1½ hr. Postoperative period not stated.
24.	Noble-Smith,* 1884 (50)	13 yr.	Typical case, bladder admits finger, ½ in. of bladder mucosa exposed, clitoris bifid.	Complete	Resection of anterior wall of wide urethra up to bladder, sutured edges together.	Continent 3–4 hrs., occasional enuresis. Postoperative period not stated.
25.	Adams,* 1885 (1)	12 yr.	External genitals show mesial cleft, starting at mons veneris and extending down into urethra.	Partial, leaks while walking only.	(1) External plastic with union of clitoris. (2) Incision from below, no symphyseotomy, internal plastic with excision of part of urethra, suture.	Improved, can hold a little while walking, but still leaks.
26.	Riesmeyer,* 1886 (65)	22 yr.	Clitoris and mons veneris divided by an aperture ¾ in. wide leading into bladder, symphysis closed.	Complete	None	—
27.	Dohrn,* 1886 (15)	18 yr.	Typical case, bladder admits finger, rudiment of sphincter present, clitoris bifid, symphysis closed.	Partial, 1–2 hr. standing, continuous leak while lying.	External plastic only.	Very slight improvement.
28.	Richelot,* 1887 (64)	6 yr.	Gutter leading to orifice, first degree clitoris bifid.	Partial, leaks on movement.	External plastic only.	Leakage at night and while playing. Improvement questionable.
29.	Gersuny,* 1889 (24)	14 yr.	Typical case, bladder admits finger, no sphincter demonstrated, clitoris bifid.	Complete	Many previous operations. (1) Resection of strip from anterior wall of urethra. (2) Pawlik's operation. (3) Torsion of urethra, 3 sittings, total 450 degrees.	First 2 operations were failures. After third, continent for 5 hr., took 4 min. to void. Postoperative period not stated.
30.	Van der Hoeven, 1889 (79)	3 yr.	Typical case, clitoris bifid, no sphincter demonstrated, symphysis closed.	Complete	Urethral funnel excised up to bladder, new urethra made from vaginal mucosa.	Continent 4 hr. Postoperative period not stated.
31.	Rutherford,* 1890 (67)	Adult	Urethra slit-like, opens in front of symphysis, clitoris partially bifid.	None	None	—
32.	Timmer, 1890 (76)	12 yr.	Typical case. Clitoris bifid, bladder admits finger.	Complete	Permanent suprapubic fistula, closure of urethra.	Small vulvar fistula remained, wore apparatus.
33.	Auffret, *1892 (6)	19 yr.	Clitoris not seen, bladder admits finger, mucosa of upper wall stuck out like "red button," symphysis closed.	Less at night than in day, could hold 1–2 hr.	External plastic, two triangular pieces removed, pulling lower wall of urethra up over orifice like a wall.	Continent 4–5 hr. Postoperative period not stated.
34.	Furst,* 1892 (23)	10 wk.	Clitoris and labia split, red streak from urethra to umbilicus (3 cm.) umbilical urachal fistula.	None	Removal and closure of urachal fistula.	Well after operation, no urethral incontinence.

TABLE I.—Continued.

	Author	Age	Description	Incontinence	Surgical treatment	Result
35.	Himmelfarb,* 1893 (32)	17½ yr.	Typical case, clitoris bifid, orifice drawn deep behind symphysis. Catheter demonstrates no sphincter, symphysis closed.	Complete	(1–6) Previous attempts to narrow urethra. (7) Urethra lengthened by flaps, bladder neck narrowed from vagina by submucosal resection of oval piece, transverse suture, urethra bent up over symphysis by skin plastic.	Continent 6 hr., never leaks, 9 mo. postoperative.
36.	Draniyzin,* 1894 (16)	9 yr.	Typical case, bifid clitoris, urethra 4 mm. in diameter. Labia minora poorly developed.	Complete	Curved incision below urethra, plastic operation on urethra.	Continent by day except occasionally when playing vigorously, occasionally wets bed at night. Several weeks postoperative.
37.	Ma'kins,* 1894 (40)	26 yr.	Typical case, urethra admitted 3 fingers.	Complete	Had previous plastics which failed. Suprapubic fistula made, urethra removed and closed.	No leakage below, wore apparatus.
38.	Petren,* 1894 (56)	16 yr.	Typical case, clitoris bifid, very small, bladder admits finger, fold posteriorly, may be sphincter rudiment, slight prolapse.	Partial, 3–4 hr. lying, ½ hr. walking, often leaks continuously.	(1) External plastic, did not heal. (2) External plastic, with more excision of urethra.	Continent, 3–5 hr. during day, 0–2 times night, 4 mo. postoperative.
39.	Ballantyne,*1896(7). Same case reported by Alexander,* 1892 (2)	13 yr.	Typical case, bladder admits finger, orifice 1½ by 1¾in., ring hymen.	Complete	(1) (Alexander) No resection, 3 rows of reefing sutures in urethra, torsion. Did not heal. (2) Same operation repeated.	Control at first, 4–8 hr. but when seen by Ballantyne 3 yr. later, totally incontinent. Urinal fitted.
40.	Mercier,* 1895 (45). Same case reported by Kirmisson, 1895 (34)	18 mo.	Typical case, bladder admits little finger, clitoris bifid, slight prolapse of bladder and rectum.	Continual leakage but a jet of urine escapes on crying.	External plastic repair.	No effect on incontinence.
41.	Kuester,* 1896 (36)	3 yr.	Bladder admits finger, clitoris bifid, symphysis closed.	Complete	External and internal plastic repair proposed, no report.	No report.
42.	Rasch,* 1897 (62)	2 yr.	Typical case, bladder admits finger, sphincter not felt, but contractions occur on faradic stimulation, slight prolapse, symphysis closed.	Complete	External plastic, deep catgut sutures to narrow neck of bladder, no excision here but a piece removed from distal urethra.	Continent, dry day and night, voids strong stream, 2 mo. postoperative.
43.	Tipjakow,* 1898 (77)	22 yr.	Urethra above and to right of clitoris, bounded by right labium majus and part of minus. 15 Hegar dilator enters urethra easily.	None until age of 21, 1½ yr. after marriage.	None mentioned.	—
44.	Wojciechowski,* 1899 (81)	21 yr.	Typical case, urethra furrow-like, anterior wall applied to symphysis, mucosa everted. Bifid clitoris, bladder admits finger.	Present, can retain 100 c.cm. in bed.	Wedge-shaped resection of urethra, torsion 90 degrees, urethra transplanted upwards.	Voids 200–400 c.cm. every 4–5 hr., no leakage day or night, 7 wk. postoperative.
45.	Audion,* 1900 (5)	6 da.	Anatomical study, premature infant, quadrilateral orifice, no clitoris, some separation of symphysis.	None	None	—
46.	Mars,* 1900 (43)	?	Case presented to Lemberg section of Galician Med. Soc. as "epispadias in a woman," no description.	?	—	—
47.	Pisemsky,* 1900 (58)	19 yr.	Clitoris bifid, urethra .75 cm. wide, fissure leads down between halves of clitoris, bladder admits finger. It is "size of apple."	Partial, can retain for 1–1½ hr.	None mentioned.	—
48.	Muratow, 1902 (49)	18 yr.	Typical case, bladder admits finger.	Present	Made new floor for urethra by turning up flap of hymen, external plastic.	Said to be "continent, holds urine 5 hr." Postoperative period not stated.
49.	Anacker, 1903 (3)	19 yr.	Typical case, urethra 1 cm. long, bladder admits finger, sphincter just felt, symphysis closed. Bladder holds 80 c.cm.	Present, some control when lying.	External plastic only.	Holds urine 3–4 hr., but leakage on coughing and after holding 5–6 hr. Postoperative period not stated.

50.	Gutschow, 1904 (28)	3 yr.	Typical case, symphysis closed.	Complete	(1) External plastic. (2) Urethrorraphy. (3) Urethrorraphy, both vaguely devised. (4) Resection of urethra, torsion 180 degrees.	No improvement.
51.	Nové-Josserand and Cotte* 1907 (51)	5½ yr.	Typical case. Also had double vagina, no prolapse.	Complete	Urethra plicated, no excision, external plastic.	No improvement.
52.	Block, 1908 (9)	19 yr.	Typical case.	Present	External plastic.	After application of pessary, patient was "continent." Certainly not a success.
53.	Pluyette, 1908 (60)	14 yr.	Typical case, clitoris bifid, erythema of vulva. Bladder holds 100 c.cm.	Present	Transverse incision to os pubis, "brought together the parts which belonged together, to serve as support for sphincter." Good healing.	No note as to result.
54.	von Mayersbach,* 1908 (44)	1½ yr.	Typical case, bladder admits finger, annular hymen, symphysis closed.	Present	External plastic, torsion of urethra 180 degrees, urethra lengthened. Some fibers of constrictor vaginæ sewed over urethra.	"Can hold water better," evidently not cured.
55.	Hackenbruch,* 1909 (30)	12 yr.	Typical case, bladder admits index finger, no sign of bladder neck.	Present	Previous operations. (1) Resection. (2) Cauterization. (3) (Hack) Reefed neck of bladder by successive rows of silk sutures. (4) 1¾ yr. later, no improvement, torsion of urethra 360 degrees.	After fourth operation, dry at all times, does not void at night. Postoperative period not stated.
56.	Goebell,* 1910 (25)	4 yr.	"Epispadias and incontinence," no further description.	Present	(1) External plastic, resutured the "split sphincter," twisted the narrowed urethra. Failure. (2) Pyramidalis muscles brought down and sutured under urethra.	Always dry in daytime except when playing, sleeps through night, voids every 3–4 hr. 7 mo. postoperative.
57.	Fleischmann,* 1911 (19)	14 yr.	Typical case, bifid clitoris, bladder admits finger, sphincter not demonstrated, ring hymen.	Present	Woelfler-Rasch operation (suture of sphincter without excision), failure. Wished to try Hackenbruch method later.	Failure.
58.	Stiles,* 1911 (71)	3 yr.	Typical case, bifid clitoris, bladder admits finger, circular hymen.	Present	Transplanted ureters into rectosigmoid.	Good result. 1 yr. after operation.
59.	Idem*	7 yr.	Same except did not admit finger so readily.	Present, but could retain 1–2 hr. while lying down.	Same operation.	Good result. 2 mo. after operation.
60.	Petkevich,* 1912 (55)	15 yr.	Typical case, bifid clitoris, urethra admits finger, but it will not pass sphincter vesicæ. Bladder holds 80 c.cm.	Complete	Bilateral wedge-shaped resection of outer urethra.	"Could withhold urine 3–4 hr." 1 or 2 wk. after operation. Patient lost sight of.
61.	Wertheim,* 1919 (80)	7 yr.	"Epispadias," no description given.	Present	Previous operations: (1 and 2) For narrowing. (3) For lengthening urethra. 3 injections of human fat, 1 paraffin injection. Failure. (4) Reefing of vesicovaginal fascia, interposition of uterus, tubal sterilization.	Pulmonary infarct after injections of fat. Final result "continent 2¼ hrs" 5 mo. after operation.
62.	Schmidt,* 1920 (69)	20 yr.	Typical case, bifid clitoris, deep cleft.	Complete	(1) Operation unsuccessful, 1914. (2) Goebell-Stoeckel pyramidalis plastic, vagina incised, urethra reefed, retention catheter.	Continent, 4 hr. during day, 7 hr. at night, 8 wk. after operation.
63.	Idem*	9 yr.	Typical case, bifid clitoris, gaping urethral opening, symphysis closed. Bladder holds 20 c.cm.	Complete	(1) Operation unsuccessful at 2 yr. (2) Same as above. Strip of rectus used on one side, pyramidalis being deficient.	Voids 3–4 times a day, 180–250 c.cm., occasionally leaks at night. 3 mo. after operation.

TABLE I.—Continued.

	Author	Age	Description	Incontinence	Surgical treatment	Result
64.	Idem*	34 yr.	Typical case, bifid clitoris, gaping urethra deep under symphysis.	Present	(1) Operation unsuccessful at 21 yr. (2) Operation unsuccessful at 33 yr. (3) Reefing of urethra and transplantation of orifice downward. (4) Pyramidalis plastic, same as above.	Voids every 2–3 hr. but often leaks. 3 mo. postoperative. Statement is made that "later," the patient was "fully continent."
65.	Reifferschied,* 1921 (63)	23 yr.	Typical case, bifid clitoris, large meatus, bladder admits finger, no sphincter found. Symphysis open but ligamentous.	Present	(1) Strips of rectus fascia 12 by 5 cm., with pyramidalis muscle, brought around bladder neck passing posterior to symphysis. No plastic on urethra. Fascia lata to defect of rectus.	"Complete cure." Postoperative period not stated.
66.	Liek,* 1923 (37)	36 yr.	Typical case, bifid clitoris, bladder admits finger.	Present	(1) Pyramidales absent, so strips of fascia were used in Goebell technique. No urethral plastic. (2) Urethra plicated to bladder, no excision, fascia undisturbed. Torsion attempted, not successful.	First operation a failure. After second, voided every 2–3 hr. during day, 4–6 hr. at night. Postoperative period not stated.
67.	Idem*	6 yr.	Typical case, bifid clitoris.	Present	Pyramidales absent, strip of fascia used in Goebell technique. Urethra plicated. Torsion tried, not accomplished.	Voided every 2–3 hr. during day, 9–10 hr. at night. Postoperative period not stated.
68.	Lower,* 1923 (38)	30 yr.	Typical case of "subsymphyseal extroversion," bladder mucosa everted, clitoris bifid.	Complete	Ureters transplanted to rectosigmoid in 2 stages.	Result excellent, emptied rectum every 7 hr. 1 yr. after operation.
69.	Thompson,* 1923 (74 and 75)	5 yr.	Typical case, clitoris said to be absent. Symphysis intact.	Present	One rectus muscle cut off ½ in. below umbilicus, brought in front of symphysis, split, sewed around urethra.	Intervals of 2 hr. or more, occasionally leaks a little, 3 mo. after operation.
70.	Marion,* 1924 (42)	?	Typical case, clitoris bifid, urethra above it.	Present	Urethra lengthened and brought up in front of symphysis by plastic operation.	"Continent." Postoperative period not stated.
71.	Potel,* 1924 (61)	Child	Typical case, clitoris bifid, urethra above it.	Present	Urethra lengthened and brought up in front of symphysis by plastic operation.	Incontinent, but retains urine by an air-bag pressing against symphysis.
72.	Deming,* 1926 (14)	21 yr.	Typical case, bifid clitoris.	Present	(1) At 16 yr. external plastic. (2) Suprapubic plastic on vesical orifice. (3) At 17 yr. V-shaped resection of urethra. (4) Transplantation of gracilis muscle to form new sphincter.	First 3 operations failed. Fourth was complete success, voids every 2–4 hr., can dance, etc., no leakage, several mo. after operation.
73.	Young,* 1926 (82)	5 yr.	Typical case, bifid clitoris, symphysis cartilaginous, diastasis recti.	Complete	(1) Previous operation, nature unknown. (2) Symphyseotomy, cystotomy, resection of urethra and vesical orifice, plastic reconstruction of urethra, bladder drained.	Voids every 2–3 hr. in day, usually once at night, never leaks, 6 mo. after operation.
74.	Sexton,* 1927 (70)	27 yr.	Typical case, bifid clitoris, but urethra is funnel shaped and sphincter is present and active. Symphysis separated.	None, but control is "slightly weak."	No treatment necessary.	
75.	Lowsley,* 1928 (39)	28 yr.	Large urethra admitting finger into bladder easily. No description of genitalia.	Present, slight, control while sitting.	(1) Suprapubic plastic on vesical orifice. (2) Sub-pubic resection of urethra and neck of bladder, closed tightly over No. 10 catheter, bladder drained.	After first operation much improved but relapsed. After second, voids every 2–5 hr. during day, never at night, no leakage, 2 yr. after operation.
76.	Bazy, no date (8)	?	No details, described as "epispadias in a female."	?	None	
77. 78. 79.	von Franque, no date (20)	?	No details, described as "epispadias in females."	?	All said to have been operated upon by Goebell's pyramidalis plastic following unsuccessful external plastics.	All said to be cured or markedly improved.

*Article consulted in the original.

when it is increased by the erect position; while in the second group of cases the comparative continence existing while the patient is erect is not due to the presence of any sphincter but to the plugging of the urethral opening by the herniated posterior bladder wall. The observation of Surmay (72) supports this view. He noted in his patient, a girl of 14, that the bladder mucosa was prolapsed through the urethral orifice, looking like "half a cherry," and that when a finger was inserted and the plug of mucosa pushed back, a gush of urine from the bladder was produced.

The degree of incompetence of the vesical sphincter does not necessarily depend on the degree of the external deformity. In Morpain's case the urethra was very large but continence was present, while in a number of other cases there was complete incontinence, the urethra being only moderately larger than normal. The incontinence is very often associated with marked inflammation of the skin of the vulva and surrounding parts due to ammoniacal decomposition of the urine with which they are constantly wet. This may be absent in cases in which there is even partial control or in which the patient has exercised unusually great care in keeping clean.

ATYPICAL CASES

Interesting sidelights on the nature of this deformity may be obtained from a study of certain atypical cases. Six of the cases here tabulated differ markedly from the usual form. The case of Tipjakow illustrates a variation in which there is lateral asymmetry. Here the urethra was above and to the right of the clitoris and the right labium minus ended anteriorly at the edge of the vesical orifice. The clitoris was described as being single and lying below and to the left of the urethral orifice, where its relations with the left labium minus were normal. It seems likely that there was really a bifid clitoris, the left half of which was much better developed than the right. In this case there was comparatively good control of urine until after marriage, when some incontinence commenced. One wonders whether this may not have been due to abnormal sexual intercourse which might easily occur because of the large urethral orifice.

The case of Testelin is quite unique. Here the external picture was perfectly characteristic of epispadias, the description being that the anterior commissure of the vagina was absent, there was a gutter over the pubis, and a large pouting orifice above the clitoris, which was single but attached to only one labium minus, recalling the situation in the case of Tipjakow. Below the

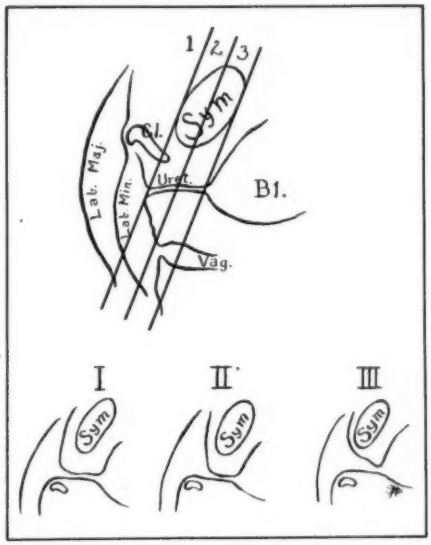

Fig. 1. Diagram showing Durand's classification of epispadias in the female. I. The vestibular zone. II. The subsymphyseal zone. III. The retrosymphyseal zone. *1*, The first or vestibular degree of epispadias, in which the urethra is practically normal but its relations to the clitoris are altered; *2*, the second or subsymphyseal degree of epispadias, in which there is a defect in the anterior wall of the urethra for about one-half its length; *3*, the third or retrosymphyseal degree of epispadias, with defect of the anterior wall of the entire urethra. The sphincter may or may not be involved.

clitoris, however, was a second orifice which had the appearance of a normal urethra. On passing sounds through these orifices it was found that each communicated with the bladder by a separate channel, the lower 6 centimeters long, the upper 4 centimeters long. Cauterization of the upper and abnormal orifice with secondary suture finally resulted in its obliteration. The patient then had perfect control of urination through the lower urethra. It is very interesting to speculate on the embryological origin of this strange deformity. One might imagine that the urogenital membrane has suffered an upward displacement of such slight degree that the cloacal tubercle arose in divided form directly to either side of it and as it developed divided in two the lowermost portion of the urethrovesical anlage (the urogenital sinus).

The cases of Penchiennati, Moeller, and Furst may be considered together. Unfortunately, the description of Penchiennati's case leaves much to be desired. There was a good sized tumor over the pubic bones covered with "common tegu-

*Article consulted in the original.

Fig. 2.

Fig. 3.

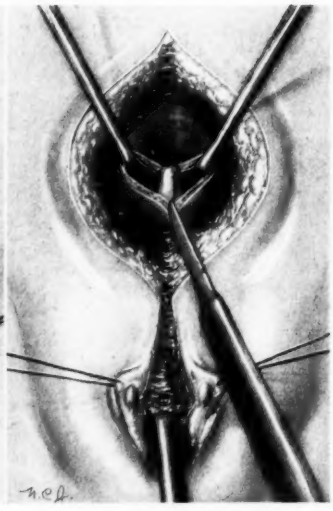

Fig. 4.

Fig. 2. Case of epispadias in the female. Appearance before operation. Note the separation of the halves of the clitoris, absence of mons veneris, wide urethra closing as a transverse slit, and normal vaginal orifice.

Fig. 3. Primary incision for cure of epispadias in the female. The scalpel is excising the rhomboid area of abnormal external skin.

Fig. 4. The bladder is being opened on a sound inserted through the urethra. The rhomboid piece of skin has been entirely removed.

ment" which seems to rule out exstrophy. There were two orifices; both discharged urine, one in the midline at the upper border of the tumor, and another one slightly to one side of the midline at the lower border of the tumor, almost at the normal site of the urethra. The symphysis was cleft, the vagina normal. The patient died at the age of 4 years and an autopsy was performed, but this was so incomplete and reported so badly that one cannot be sure what the internal arrangements were. It seems most likely that the upper orifice represented a patent urachus, while the lower one was an epispadiac urethra. Moeller's case is similar except that there was no urachal opening. The symphysis was separated and there was a hernia of the lower abdominal wall containing the bladder which was, however, entirely closed on its anterior aspect. Inferior to this hernia was a urethral orifice which had an appearance corresponding exactly with the typical epispadias just described. This case gives strong additional evidence that even where there is a tendency to faulty development of the lower urinary tract, a separation of the symphysis does not necessarily mean that there will be exstrophy. In Furst's case it is not definitely stated that the symphysis was open but one feels that it must have been. There was no definite hernia of the anterior abdominal wall but there was a urachal fistula, a red streak ran from the urachal fistula to the urethra, the labia were separated anteriorly and the clitoris was bifid. In spite of all this evidence of faulty development of the lower urinary tract, the sphincter was evidently well formed since after closure of the urachal fistula there was no incontinence through the urethra.

Unfortunately the case of Audion was described so imperfectly that one cannot be certain as to whether or not it represents an atypical malformation in a premature infant. It is stated that there was a large quadrilateral urethral orifice, that the clitoris was entirely missing, and that there was some separation of the symphysis. It is possible that a more complete description would place this case among the typical cases of epispadias.

CLASSIFICATION

In considering such cases as those just described and other cases of atypical and incomplete exstrophy of the bladder, it is evident that a nomenclature and delimitation of various groups must be established. Where does epispadias leave off and exstrophy begin? Older writers have attempted to lay down the rule that all cases in which the symphysis is closed must be regarded

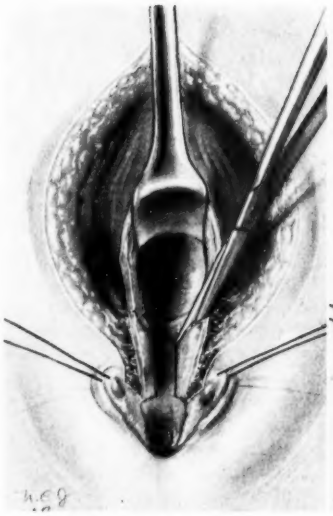

Fig. 5.

Fig. 5. The symphysis has been divided and the entire bladder and urethra have been laid open. Pieces of mucosa are being excised laterally, leaving just enough for a normal sized urethra. Note the relation of the new urethra to the ureters and the inter-ureteric bar.

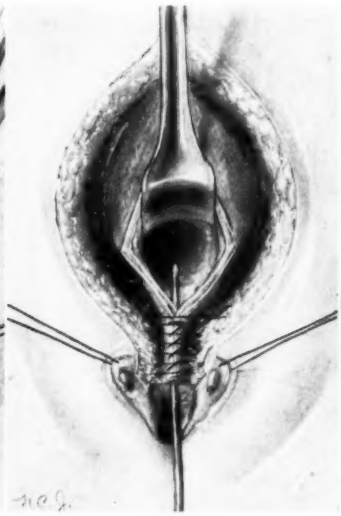

Fig. 6.

Fig. 6. The new urethra reconstructed with continuous suture.

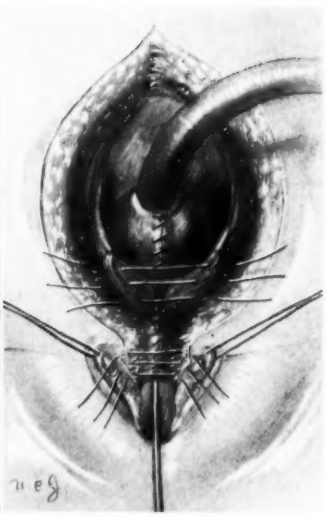

Fig. 7.

Fig. 7. The reconstruction is complete. The symphysis is sutured with No. 3 chromic catgut. The halves of the clitoris are drawn together with plain catgut sutures.

as epispadias, while if the symphysis is open, one is really dealing with mild grades of exstrophy. This dictum is certainly untenable, since no one would think of applying the name of exstrophy to the cases of Moeller, Furst, or Sexton. To meet this difficulty, Durand devised an entirely new term, *extroversion*, which was applied to those cases in which the urethral defect was extensive, the sphincter undeveloped, and the bladder mucosa prolapsed. In the interest of simplicity, however, it would seem advisable not to multiply the terms in use, and the name epispadias can be applied perfectly reasonably and understandably to all cases in which there is no open cleft at any point in the anterior wall of the bladder, just as in the male. We can then distinguish groups of epispadias. Durand formulated three groups. He considered that there were three zones: first, the vestibular zone, bounded by a line tangential to the anterior surface of the symphysis and passing through the urethral meatus; second, a subsymphyseal zone extending between the line just mentioned and a line drawn between the middle of the symphysis and the midpoint of the urethra; third, the retrosymphyseal zone, including the tissue between the last named line and a line parallel to it passing through the vesical orifice. Thus, if the deformity is confined to the vestibular zone, one has the first degree of epispadias, consisting only of a division of the clitoris and an upward displacement of the urethral orifice. With this type there should be no incontinence. In the second degree, the deformity extends into the subsymphyseal zone with a defective anterior surface of the urethra here giving rise to a wide, funnel-shaped orifice, but again the sphincteric apparatus should not be involved and urinary control should be present. In the third degree, the defect in the anterior wall of the urethra extends back into the retrosymphyseal zone, usually involving to a greater or lesser extent the internal sphincter of the bladder with resultant incontinence. When the sphincter is greatly involved in the deformity and the vesical orifice much widened, there may be prolapse of the posterior wall of the bladder.

A careful study of the case reports accompanying this article will show that Durand's classification is somewhat too dogmatic, since incontinence may be present with slight degrees of urethral deformity, while in other cases excellent urinary control may exist along with extreme urethral deformity. The classification, however, has some usefulness from an anatomical point of view; but

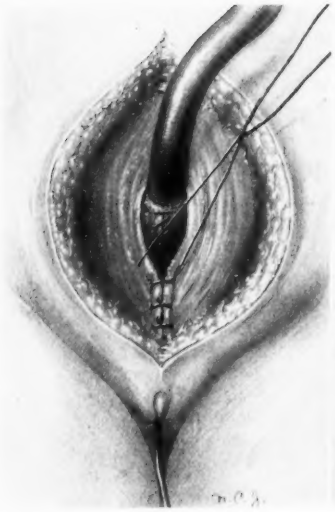

Fig. 8.

Fig. 9.

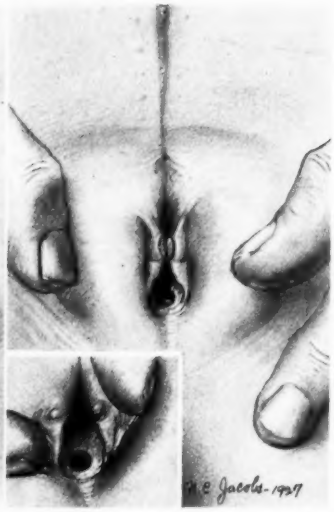

Fig. 10.

Fig. 8. Closure of the abdominal muscles. Note that the two halves of the clitoris are now drawn closely together.

Fig. 9. The operation has been completed, and a cigarette drain placed in the prevesical space. The skin is closed with metal skin clips.

Fig. 10. Final result. The insert shows that the halves of the clitoris have become slightly separated but between them can be seen a urethral orifice which has an entirely normal appearance.

from a surgical point of view it seems to me that there should be but two groups, namely: epispadias without incontinence and epispadias with incontinence. Epispadias without incontinence requires no treatment, while in epispadias with incontinence the surgical principles to be followed are exactly the same regardless of the extent of the deformity.

Table I gives the anatomical description, so far as it may be gleaned from the literature, of the cases which have been reported, together with an account of the treatment employed and the results obtained. Analysis of the table shows that it includes 64 cases which are undoubtedly typical epispadias. In 5 of these there was no incontinence, leaving 59 cases of typical epispadias with incontinence. Six of the cases are classed as atypical, while 10 must be listed as questionable owing to faulty or incomplete description, but in each of these there is some good reason to believe that a case of true epispadias is represented. If we include these probable cases there is a total of 69 cases of typical epispadias with incontinence. These figures indicate that the condition, while rare, is not one of the great curiosities and that it is, therefore, worth while for every urological surgeon to know how to proceed should a case come to his attention. The following report is an account of a case seen by the author.

S.M.H., 5791, E.R.T., 4 years of age, was first seen on March 20, 1927. The complaint was of complete incontinence. Apparently the child had not been dry at any time even for a few minutes. Aside from this, the general health had been good but lately there had been a great deal of discomfort and disability due to increase in the irritation of the skin of the external genitalia and anterior surfaces of the thighs. Along with this there had been noted from time to time a prolapse of the rectum, which was easily replaced. There had also been at times a prolapse of the bladder mucosa through the urethra and on a few occasions the replacement of this had been attended with difficulty. No operation had been performed.

Examination was negative except for the external genitalia, which presented an appearance entirely typical of epispadias. The hymen was circular and apparently normal. The rectum appeared normal. There was no prolapse at the time of examination. The opening into the bladder was very large but there was no prolapse. Urine dripped continuously. The halves of the clitoris were small and equal and separated by about 1½ centimeters. The symphysis was closed but still cartilaginous. There was very marked eczema of the vulva and thighs with ammoniacal odor. On March 28, after careful attention in the hospital, the child was entirely free from eczema. The urine was clear and uninfected.

Operation. Under ether anæsthesia an incision was made starting about 5 centimeters above the symphysis and extending downward to the lower border of the symphysis. From this point a separate oblique incision was carried

down on each side to the bases of the split glans of the clitoris. From there the incisions turned inward to the anterior aspect of the enlarged urethral orifice, thus including in the rhomboidal space designed for excision practically all of the abnormal, hairless skin occupying the depressed area at the site of the mons veneris and anterior commissure. Dissection was then carried down to the bladder above the symphysis, the peritoneum pushed back, and the bladder incised. With retractors in place, one could see that the vesical mucosa was smooth, pale and normal in appearance in all particulars except that the urethral orifice was dilated. Clear urine flowed from the ureters. The bladder wall was of normal thickness and appeared to be well muscled. The rhomboidal flap at the lower end of the incision was then dissected off and retracted down, and the incision carried down on the urethra and symphysis. The cartilaginous symphysis was divided and the urethra split all the way up to the bladder so that the entire tract was laid open. Inspection then showed that the urethra was about 30 millimeters in circumference and that there was no line of demarcation between urethra and bladder. No transverse folds or bands were seen.

A point was selected corresponding, by its relations with the ureteral orifices, to the uvula of Lieutaud and the urethral mucous membrane excised on both sides up to the level of this point, leaving a strip about 7 millimeters wide and 12 millimeters long, with parallel edges, from which the new urethra was to be formed. Incisions were then carried obliquely upward on each side to the cut edges of the bladder, completing the excision of redundant mucosa. An artery, apparently the inferior vesical, was encountered on each side and clamped and ligated. Inspection then showed some masses of muscle on either side of the site of the new orifice. These were deeply caught up with a suture of No. 0 chromic catgut, which came out just at the edge of the mucous membrane. When this suture was drawn together it created a new and small vesical orifice, surrounded by a good mass of muscle which was expected to have a sphincter action. The same strand was used and the new urethra reconstructed by a continuous stitch with similar deep bites, down to the external orifice. It was then brought back, making a second row burying the new urethra, and tied at the level of the vesical orifice.

Another continuous No. 0 chromic catgut suture closed the bladder except at the upper end of the incision, where a large bladder drainage tube was left in place. The symphysis was brought together with 4 No. 3 chromic catgut sutures. Closure of the skin for the short distance from the new urethra to the clitoris was by No. 0 plain catgut, interrupted sutures, the two halves of the clitoris being thus brought together. The remainder of the incision was closed in the usual way, metal clips being used for the skin. The suturing of the urethra was done over a silver probe, and at the end it was tight enough to grasp the probe moderately. The probe was withdrawn at the completion of the operation.

Rather marked bleeding began 36 hours after the operation but lasted only a short time and apparently did the patient little harm. One small transfusion was given. The tube was removed from the bladder on the twenty-first day. The patient was discharged from the hospital on April 28. As much as 120 cubic centimeters could be voided at a time but dribbling was more or less continuous.

June 23. The patient could void about one-half cupful every morning and evening but there was still some dribbling. No eczema was present. Under anæsthesia, examination showed the entire wound to be well healed except that the halves of the clitoris were 7 or 8 millimeters apart. The urethral orifice appeared normal and no urine leaked from it. A No. 12 catheter entered the bladder without difficulty and clear urine was withdrawn. There was no leakage around the catheter when 120 cubic centimeters of fluid were injected.

September 7. Since the previous examination no leakage of urine had occurred at any time, day or night, in spite of a severe attack of bronchitis 6 weeks before. The usual interval of voiding was 1½ to 3 hours during the day and the maximum interval was 6½ hours. The child usually slept 10 to 12 hours at night without voiding. The urine was clear on examination. The patient had gained tremendously in every way.

TREATMENT

For purposes of discussion, the methods that have been followed in treating epispadias in the female may be classified as (1) plastic operations, (2) reefing operations, (3) muscle transplantation, (4) torsion of the urethra, (5) cauterization, (6) interposition of uterus, (7) transplantation of the ureters, and (8) closure of urethra with establishment of suprapubic fistula.

1. *Plastic operations.* These may be divided into (a) external plastics in which the external genitalia have been restored to a condition as near normal as possible and the urethra has been repaired by the excision of portions of its redundant wall reaching upward for variable distances but not far enough to include the sphincteric muscle of the bladder; and (b) internal plastics, in which the repair has been carried upward to include the region of the internal sphincter, the vesical orifice, and a portion of the anterior wall of the bladder. Many of the early cases were operated upon by the external plastic method because of a lack of understanding of the internal situation causing incontinence, and merely with the thought of restoring the external appearances.

In later developments the idea appeared that the necessary requirement was lengthening and narrowing of the urethra followed later by efforts to create a bend or kink in its course. Surprisingly enough, 5 of the cases operated upon in this manner are reported as complete cures. It should, however, be stated at this point that reports of complete cures unaccompanied by specific statements covering a long period of observation after the operation should be accepted with much reserve. For example, one case (No. 39) was reported by Alexander in 1892 as a complete cure. The same case was observed by Ballantyne 3 years later and at that time the incontinence had returned and was complete. It is noted in many cases that while the immediate result may be good, incontinence will return a few weeks later as a result of the subsidence of the œdema and inflammatory reaction around the urethra.

TABLE II. — CLASSIFICATION OF OPERATIVE PROCEDURES USED FOR EPISPADIAS IN FEMALES AND RESULTS OBTAINED*

Operative procedure	Well		Occasional leakage		Some improvement		No improvement		Total operations not completely successful, per cent	Total cases
	Cases	Per cent	Cases	Per cent	Cases	Per cent	Cases	Per cent		
External plastic only	5	36	3	21	3	21	3	21	64	14
External plastic and deep plastic (resection) without deviation of urine	1	25	2	50	1	25	0		75	4
External plastic and deep plastic (resection) with suprapubic drainage	3	100	0		0		0			3
Reefing of urethra and external plastic	0		0		0		1	100		1
Reefing of urethra and torsion	0		0		0		1	100		1
Reefing of vesical neck and external plastic	1	50	0		0		1	50	50	2
Reefing of vesical neck and torsion	1	100	0		0		0			1
Torsion of urethra and external plastic	2	50	0		1	25	1	25	50	4
Pyramidalis plastic (alone)	1	100	0		0		0			1
Pyramidalis plastic and external plastic	5	71	2	29	0		0		29	7
Pyramidalis plastic and reefing of urethra	2	100	0		0		0			2
Rectus plastic, anterior to symphysis	0		1	100	0		0		100	1
Gracilis plastic, external and deep urethral plastic. Suprapubic drainage	1	100	0		0		0			1
Cauterization	0		0		0		1	100	100	1
Excision of urethra, new urethra formed from vagina	1	100	0		0		0			1
Submucous resection of vesical orifice posteriorly through vagina, urethra lengthened	1	100	0		0		0			1
Reefing vesicovaginal septum, interposition of uterus, sterilization, external plastic	1	100	0		0		0			1
Operation not described	0		0		0		1	100	100	1
Total	25	53	8	17	5	11	9	19	47	47
Transplantation of ureters	3	100	0		0		0			3
Closure of urethra, suprapubic fistula	1	50	1	50	0		0		50	2
No operation										14

*The results are taken from the published articles and may in some cases be somewhat optimistic.

2. *Reefing operations.* In another group of cases restoration of the urethra was attempted by means of reefing sutures applied through its walls, reducing the caliber without any excision of tissue. Practically all of these attempts failed since they violated a fundamental surgical principle in aiming to cause the cohesion of mucous surfaces in apposition by means of sutures. Here again the areas covered varied widely, in some cases including only the external portion of the urethra and in others including the entire urethra and sphincteric apparatus.

3. *Muscle plastic operations.* Some surgeons, feeling that the faulty development of the muscular apparatus precludes any successful attempt to restore normal conditions by plastic operation, have attempted to supply new sphincteric apparatus by transplanting a voluntary muscle in the form of a ring around the urethra. In some cases there was previous reduction in size of the urethra by plastic procedures, in others none. The muscles used have been the pyramidalis muscle, brought down either with or without a strip of rectus fascia attached, behind the symphysis to the juxtavesical portion of the urethra; strips of rectus muscle brought down either behind or in front of the symphysis to surround the urethra; and the gracilis muscle divided at its midpoint and brought across into the peri-

neum to surround the urethra. Some good results have been obtained from each of these methods.

4. *Torsion of the urethra.* This operation represents an effort to bring the walls of the urethra into close apposition by another means. The urethra is freed up to its attachment to the bladder, twisted through an arc varying from 90 to 480 degrees, the latter in several sittings, and sutured into place again at the outer end. This operation has had a great vogue not only in epispadias but in traumatic incontinence of women, but has many disadvantages. It may be followed by gangrene of the urethra or stricture, and in many cases has failed to produce the desired result.

5. *Cauterization.* This method has been used but twice, once to cause obliteration of an accessory urethral canal (Case 7) and again in an effort to reduce the caliber of an epispadiac urethra. In the latter case it failed completely as might have been expected.

6. *Interposition of uterus.* This operation has been utilized but once. At the same time the vesicovaginal fascia was shortened by a reefing procedure and the patient was sterilized by a resection of the tubes. The result was good but there now seems no excuse for sterilizing the patient in order to cure epispadias.

7. *Transplantation of the ureters.* The many failures following plastic and other direct operations have induced two surgeons to attempt transplantation of the ureters into the rectosigmoid. The results have been good in all of the cases reported but here again in the light of considerations to be discussed later, it seems that the procedure is unnecessarily severe and radical.

8. *Obliteration of urethra and establishment of suprapubic fistula.* This operation, which is truly a counsel of despair, has been done in 2 cases, but requires no further consideration at this time.

Apparently the first operation for epispadias in the female was performed by Roeser in 1860. He excised portions of skin externally so that the halves of the clitoris and the upper parts of the labia could be drawn together. He also excised some of the redundant urethra but only for a portion of its length. As a result of this operation the patient's condition was improved but there was still leakage on coughing or straining and at night.

Pippingskold was the next to operate, in 1876, but no description of the operation is given and there was no improvement in the incontinence. Moericke in 1880 made a marked advance. After four unsuccessful external plastics, he dissected the urethra deep into the bladder, including the region of the sphincter, and sutured the edges of the resected area together. He also lengthened the urethra and kinked it up over the symphysis. The result was somewhat better. The patient could retain urine for 4 hours, but there was still a little leakage on coughing or straining. In the case of Frommel in 1882 a similar operation was performed and the statement was made that the patient could retain the urine for 4 hours without any leakage. If this is true, it is the first instance of a cure of epispadias in the female.

There were no further innovations until Gersuny in 1889 conceived the idea of twisting the urethra on its long axis to bring its walls in close apposition. In his case he twisted the urethra, in 3 sittings, through 450 degrees, after which the patient could retain urine for 5 hours and did not leak, but had marked difficulty of urination, taking 4 minutes to empty the bladder. Van der Hoeven, in the same year, excised the entire urethra, forming a new one by a plastic procedure from vaginal mucosa, with what is stated to be a good result.

Himmelfarb in 1893 followed an entirely new plan. His incision was made in the vagina and through this opening he resected an oval piece from the region of the vesical orifice posteriorly, without cutting through the mucosa. The edges of this resected area, presumably made up of muscular tissue, were then sutured together. The urethra was also lengthened and the result was apparently very satisfactory, the patient being able to retain the urine for 6 hours, without any leakage, 9 months after the operation. Similar operations are still done for traumatic incontinence in women, and with success, but in epispadias the defect is anterior and the resection and repair should be done anteriorly.

Alexander in 1892 was the first to attempt narrowing of the urethra by means of reefing sutures. In spite of a repetition of the procedure, the failure was complete. Von Mayersbach in 1908 seems to have been the first to suggest strengthening the sphincter by transplantation of voluntary muscle but he used for this purpose "some fibers of the constrictor vaginæ," which could scarcely be expected to be satisfactory for this purpose.

The first practicable contribution on the basis of muscle transplantation was that of Goebell in 1910. He brought the pyramidalis muscles down behind the symphysis pubis and sutured them together beneath the urethra. The results were good. This operation was cleverly devised and took advantage of the fact that the nerve and blood supply of the pyramidalis muscle enter it very near its point of origin and need not be dis-

turbed by the operation. Unfortunately, the pyramidalis is often poorly developed, so that a number of surgeons, who have attempted this operation, have not found sufficient material with which to carry it out. The idea was further extended by Thompson, in 1923, who, finding the pyramidalis deficient, cut a long strip from the rectus abdominalis and brought it down in front of the symphysis, split its end longitudinally, and sewed these halves around the urethra. Some of the operations which make use of the pyramidalis muscles have failed, probably because of the poor development of the muscle or because of unintentional interference with its nerve or blood supply at the time of operation.

In 1911 Stiles concluded from a study of the literature that all of the operations to date might be expected to fail and, therefore, treated his cases by transplanting the ureters into the rectosigmoid. Wertheim in 1919, after numerous efforts to help his case by other means, including injections of fat and paraffin, did a complicated operation in which the uterus was tipped forward and interposed beneath the region of the vesical orifice. While this apparently produced a good result, it made sterilization of the patient necessary and has not been imitated by any other surgeon.

It is remarkable that in not one of the cases operated upon up to 1923 is there any mention of a diversion of the urine by means of a drainage tube in the bladder. In some cases the patients were left to pass their urine over the freshly sutured field of operation and in others a retention catheter was left in place for a certain length of time. This seems remarkable inasmuch as other surgeons, who had been operating upon urethral defects in the male, particularly hypospadias, had long before this discovered that diversion of the urine is absolutely necessary in order to secure healing in a sufficiently large proportion of the cases. Apparently the first to put this principle into practice in a case of female epispadias was Young, who performed his operation in 1923. This operation is of particular interest from several points of view. The surgeon, through his previous work on male epispadias, was familiar with the studies of von Kalischer and Zangemeister, who showed that in cases of male epispadias the internal sphincter muscle exists as a crescentic mass, with its convexity posterior, and anterior ends being ununited because of a defect in the anterior wall of the vesical orifice. He, therefore, deliberately planned to freshen the ends of this muscle, excise the redundant mucosa between them, and suture them together around the newly formed vesical orifice. In order to do this properly, he made a wide exposure of the entire bladder and urethra. Since the patient was only 5 years old, he cut through the cartilaginous symphysis and thereby obtained a perfect view of the situation. The resection of the urethra and vesical orifice was wide, leaving just enough mucosa for the reconstruction. A drainage tube was placed in the bladder to divert the urine during the period of healing and the result was entirely satisfactory, the patient being free of incontinence.

About the same time Deming operated upon a patient 21 years of age. The operation upon the vesical orifice was done as a separate step but bladder drainage was also used. Owing either to the scars of previous operations, to unusually great aplasia of the sphincter, or to some other factor, the result was not successful, so that he had recourse to a muscle plastic, using the gracilis muscle. This idea was quite original with Deming and has much to recommend it. The gracilis muscle is larger than any of the other muscles that have been used for the purpose; it is not apt to be undeveloped; a sufficient length is always available, and the blood and nerve supply are so arranged that they are not interfered with if the muscle is cut in its midportion and its upper half carried up into the perineum. This procedure was followed by complete success and has since been successfully repeated by Player and Callendar (59) in a case of male incontinence.

Lowsley's case is an unusual one. The situation, as far as the sphincter muscle and urethra were concerned, was the same as in cases of epispadias, but he states that there was no abnormality whatsoever of the external genitalia. His plan of operation was similar to that of Young but since his patient was 28 years of age, it was not necessary to divide the symphysis in order to obtain suitable exposure. The result was entirely successful. In the case reported in this article, the method followed was essentially similar to that of Young. There were slight differences in the trace of the cutaneous incision, with the idea of producing a better cosmetic result in the region of the anterior commissure. No instrument was left in the urethra at the close of the operation, but bladder drainage was established. It was further found that silver wires were unnecessary for closure of the symphysis, chromic catgut sutures proving satisfactory.

SUMMARY

In the light of the foregoing considerations, it appears obvious that there is no occasion for pes-

simism as to the results of plastic operations for epispadias in the female. In practically every case in which the surgical procedures have been properly planned and executed, complete success has been attained. Such operations as transplantation of the ureters should, therefore, be entirely abandoned for this condition. Even though a satisfactory functional result may be obtained it is unnecessary to subject the patient to the risk of ascending renal infection, which is always present after this operation. Gersuny's operation of torsion of the urethra should also be abandoned, not only in cases of epispadias but for all cases of female incontinence. The evil results from it are too numerous and include gangrene of the urethra, urethral stricture, urethrocele with stone formation and urethrovaginal fistula, while even in the absence of these there are reports of failure to relieve the incontinence. In a case known to the author a retention of urine followed a Gersuny operation and the urethral orifice could not be located when catheterization was attempted. As a result false passages were produced and the patient's condition made worse than before.

The method to be followed is obvious. It should consist of two steps only, the second of which is usually unnecessary. The first should be a thoroughgoing plastic repair of the defect, including the following essential points: (1) Wide exposure of the affected areas. (2) Sufficient and thoroughly controlled excision of excessive mucosa, done under vision. It is very important to make the urethra small enough; if it is too small it can easily be dilated, if it is too large the operation is a failure and must be repeated. (3) Careful suture of the halves of the defective internal sphincter muscle over the anterior aspect of the newly formed vesical orifice. (4) Diversion of the urine during the period of healing by a drainage tube in the bladder. This procedure can be relied upon to produce a cure in most cases in which it is properly carried out. Should it for any reason fail, the second stage should then be the performance of Deming's gracilis muscle plastic operation. There is excellent reason to believe that these methods can be relied upon to produce a cure in practically every case of epispadias in the female.

BIBLIOGRAPHY

1. Adams. Glasgow M. J., 1885, xxiv, 388.
2. Alexander. J. Cutan. & Genito-Urin. Dis., 1892, x, 253–268.
3. Anacker. Inaugural Dissertation, Strassburg, 1903.
4. Arnaud. Mém. de chir., i, 374. Quoted by Morpain.
5. Audion. Bull. et mém. Soc. anat. de Par., 1900, lxxxv, 29–31.
6. Auffret. Rev. de chir., 1892, xii, 444–445.
7. Ballantyne. Edinburgh Hosp. Rep., 1896, iv, 249–277.
8. Bazy. Quoted by Richelot.
9. Block. Inaugural Dissertation, Strassburg, 1908.
10. Bon and Duncan. Edinb. M. & S. J., 1805.
11. Burckhardt. Handb. d. Urol., 1906, iii, 73.
12. Campbell. Tr. Am. Gynec. Soc., 1883, viii, 146–153.
13. Coustou. Bull. Soc. anat. de Par., 1875, l, 496.
14. Deming, J. Am. M. Ass., 1926, lxxxvi, 822–825.
15. Dohrn. Ztschr. f. Geburtsh. u. Gynaek., 1886, xii, 117–120.
16. Draniyzin. J. Akush. i Zhensk Boliez., St. Petersburg, 1894, vii, 567–572.
17. Durand. Ann. de gynéc., 1895, xliv, 1431.
18. Emmet. Am. J. Obst., 1872–73, v, 147.
19. Fleischmann. Zentralbl. f. Gynaek., 1911, xxxv, 514–515.
20. Franque. Quoted by Reifferschied.
21. Frommel. Ztschr. f. Geburtsh. u. Gynaek., 1882, vii, 430–433.
22. Funk. Wchnbl. d. k. k. Gesellsch. d. Aerzte in Wien., 1870, ix (xxvi), 235.
23. Furst. Arch. f. Kinderh., 1892, xiv, 430–433.
24. Gersuny. Zentralbl. f. Chir., 1889, lx, 433–437.
25. Goebell. Ztschr. f. gynaek. Urol., 1910, ii, 187–191.
26. Gosselin. Gaz. d. hôp., 1859, xxxvii, 14. Quoted by Nunez.
27. Gottschalk. Inaugural Dissertation, Wuerzburg, 1883. Quoted by Nové-Josserand.
28. Gutschow. Inaugural Dissertation, Rostock, 1904.
29. Guyon. Thèse de doct., Paris, 1863.
30. Hackenbruch. Med. Klin., 1909, v, 1150–1153.
31. Henle. Ztschr. f. Rationelle Med., 1855, vi, 343–344.
32. Himmelfarb. Arch. f. Gynaek., 1893, xliv, 312–321.
33. Johnson. Young's Practice of Urology, 1926, ii, 104–108.
34. Kirmisson. Acad. de méd., Paris, 1895, July 30.
35. Kleinwaechter. Monatschr. f. Geburtsh. u. Frauenkr., 1869, xxxiv, ii, 81–85.
36. Kuester. Wien. klin. Wchnschr., 1896, ix, 195.
37. Liek. Zentralbl. f. Gynaek., 1923, xlvii, 604–606.
38. Lower. J. Urol., 1923, x, 149–157.
39. Lowsley. J. Am. M. Ass., 1928, xc, 511–516.
40. Makins. Lancet, 1894, ii, 1140–1142.
41. Malgaigne. Rev. méd. chir. de Paris, 1849, vi, 374. Quoted by Nunez.
42. Marion. Bull. et mém. Soc. nat. de chir., 1924, l, 330–333.
43. Mars. Przegl. lek., 1900, xxxix, 389.
44. Mayersbach. Wien. klin. Wchnschr., 1908, xxi, 1813–1816.
45. Mercier. Rev. d'orthop., 1895, vi, 352–368.
46. Moeller. Arch. f. path. Anat., 1864, xxix, 205–207.
47. Moericke. Ztschr. f. Geburtsh. u. Gynaek., 1880, v, 324–333.
48. Morpain. Gaz. hebd. de méd. et de chir., 1855, ii, 436–439.
49. Muratow. Russk. Vrach., 1902, xxx. Abstracted Centralbl. f. Chir., 1902, xxxix, 1078.
50. Noble-Smith. Brit. M. J., 1884, ii, 561.
51. Nové-Josserand and Cotte. Rev. de gynéc. et de chir. abd., 1907, xi, 963–1006.
52. Nunez. Thèse de doct., Paris, 1882, ci, 90.
53. Penchiennati. Mém. Acad. roy. d. sc., Turin, 1784–85, i, 387–390.
54. Petit, J. L. Oeuvres completes Traité des Mal. Chir., 1774, 798. Quoted by Surmay.
55. Petkevich. J. Akush. i Zhensk. Boliëz., 1912, xxvii, 1477.

56. Petren. Nord. med. Ark., 1894, iv (xxvi), 1–12.
57. Pippingskold. Finska läk.-sällsk, handl., Helsingfors, 1876, xvii, 49. Abstracted in Jahresb. u. d. Leistung. u. Forts. d. ges. Med., 1876, i, 300.
58. Pisemsky. Vrach, 1900, xxi, 777.
59. Player and Callendar. J. Am. M. Ass., 1927, lxxxviii, 989–991.
60. Pluyette. Rev. prat. d. mal. d. org. gén. urin., 1908, xxvii. Abstracted in Zentralbl. f. Gynaek., 1909, xxxiii, 828.
61. Potel. Gynéc. et obst., 1924, x, 94–101.
62. Rasch. Beitr. z. klin. Chir., 1897, xviii, 557–594.
63. Reifferschied. Zentralbl. f. Gynaek., 1921, xlv, 97–102.
64. Richelot. Unión méd., 1887, xliii, 365–368.
65. Riesmeyer. St. Louis Cour. Med., 1886, xv, 515.
66. Roeser. Wuerttemb. Med. Korr.-Bl., 1860, 157. Quoted by Gurlt. Arch. f. klin. Chir., 1862, iii, 455–456. Jahresbericht, 1860–61.
67. Rutherford. Med. Rec., 1890, Nov., 102.
68. Savastitskii. Laitop. khirurg. Obsh. v. Mosk., 1873–75, i, 292. Quoted by Ballantyne.
69. Schmidt. Deutsche med. Wchnschr., 1920, xlvi, 910–912.
70. Sexton. J. Urol., 1927, xviii, 663–666.
71. Stiles. Surg., Gynec. & Obst., 1911, xiii, 127–240.
72. Surmay. Unión méd., 1866, xxxii, 580–583.
73. Testelin. J. de méd., chir. et pharm., 1854, xix, 455–458.
74. Thompson. Brit. J. Child. Dis., 1923, xx, 146–151.
75. Idem. Guy's Hosp. Gaz., 1923, xxxvii, 184.
76. Timmer. Nederl. Tijdschr. v. Geneesk., 1890, xxvi, 637–641.
77. Tipjakow. Med. Obozr., 1898, l, 650–651.
78. Torrilat. Arch. prov. de chir., 1902.
79. Van der Hoeven. Inaugural Dissertation, Leyden, 1889.
80. Wertheim. Wien. klin. Wchnschr., 1919, xxxii, 888.
81. Wojciechowski. Przegl. lek., 1899, xxxviii, 259–262.
82. Young. Practice of Urology, 1926, ii, 639–642.

THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP BY OPEN OPERATION[1]

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IN the treatment of congenital dislocation of the hip, operative interference presents certain advantages over mechanical and closed manipulative methods—advantages that justify a more extensive use of the open procedure. Operative treatment affords the opportunity to examine the existing pathology. Not infrequently, the study of the pathological changes reveals a dislocation so marked, or a capsule so misshapen, or an acetabulum so filled with adherent tissue, that the impossibility of obtaining reduction by closed manipulative treatment is immediately recognized. The surgical dangers of open operation are very slight, shock is seldom experienced, and there is little damage to the tissues. On the other hand, so much force may be required to reduce a dislocation by manual procedures or traction machines that the soft parts are severely traumatized. Open intervention is the only procedure possible in adult cases of dislocation, which, unless relieved, come to extreme disability, since the patient suffers from symptoms of an arthritic nature as well as from instability.

The hesitancy of operators to use the open method more widely may be traced to the conservative teachings of many of our instructors. Then, too, manipulative procedures have been practised so long in many of the children's hospitals, that the adoption of the open method might be interpreted as an admission of the failure of the closed manipulative measures. To those who have been trained recently in surgical procedure, and who have learned the technique of the open method from a competent surgeon, the open approach is logical.

INDICATIONS

In children from 4 to 8 years of age, operative interference is indicated to effect reduction when one or two closed manipulations have not been successful.

In children more than 8 years of age and in adolescents, open operation is the method of choice for reducing a dislocation. Manipulative treatment in such cases is liable to result in extensive trauma; especially is this true if the child is of the resistant type.

In adults, whose age excludes the possibility of obtaining a satisfactory functional result, open operation is indicated to correct deformity, if present, and to relieve pain and stiffness, thereby avoiding arthritic complications which eventually develop in such cases.

PATHOLOGY

The chief obstacles to reduction lie in the alteration of the soft structures and in the anteversion of the femoral head and neck. In some cases, changes in the acetabulum make reduction difficult.

The superior capsule is extremely dilated as the result of the pressure of the femoral head against it when the patient bears weight. The inferior capsule is adherent to the acetabulum and often fills the cavity except for a small opening through which the teres ligament passes to join the head. At the upper posterior rim of the acetabulum, where the teres ligament comes out, the capsule is usually contracted in the shape of an *hour-glass*. This contraction of the inferior capsule and its adherence to the acetabulum form the great barriers to reduction by closed manipulative methods.

The femoral head and neck practically always show anteversion, and not infrequently the neck is shortened and misshapen as well as twisted. This rotation of the head and neck constitutes another obstacle to reduction.

The acetabulum assumes a triangular shape. Its rim becomes flattened as the result of the pull of the capsule upward. The socket appears to be shallow. In some cases the cavity actually may be of little depth, but, as a rule, the shallow appearance is due to the fact that the acetabulum is filled with connective tissue, which is completely covered over by the adherent inferior capsule.

OPERATIVE TREATMENT

The selection of the operation. Once open operation has been decided upon, the choice of the operative method will be determined by the following factors: the age of the patient, the position of the femoral head, and the pathological condition of the acetabulum. The operator may advise a simple replacement of the femoral head, a reconstruction operation on the acetabulum or head, or an arthrodesis.

[1]From the MacAusland Orthopedic Clinics.

Fig. 1. Congenital hip skid (author's).

Simple replacement is the ideal method of treatment for it insures both a good anatomical and functional recovery. This procedure is applicable to cases in which the acetabulum is of sufficient depth to retain the femoral head, and in which the shape of the head itself is normal or nearly so. The technique by which the head is restored to position varies with the operator. If marked internal rotation persists after reduction, it may be corrected by an osteotomy of the femur.

The author's method of reduction. A 2-day preparation is given to the operative field, which includes the knee joint, the inner and posterior parts of the thigh up to the groin, and the section contained between the anterior midline and the posterior midline of the body and extending well above the crest of the ilium. The patient is draped with the affected leg left exposed so as to facilitate manipulative treatment.

An incision 6 to 8 inches in length is made, beginning at the anterior superior spine and extending downward, in a slightly curved direction, to the outer part of the thigh. The skin edges are wiped with alcohol and walled off with towels. A longitudinal incision is made through the fascia, care being taken not to carry it too low, because of the danger of injuring the internal saphenous nerve leading to the vastus externus. The external femoral artery, which usually lies in the lower part of the wound, is clamped off and tied. The rectus femoris and the sartorius are defined and retracted to the inner side, and the tensor vaginæ femoris and the gluteus maximus and medius are exposed and retracted to the outer side. All tissue about the capsule is pushed back by blunt dissection.

An incision running parallel to the shaft of the femur is made through the capsule and lengthened at each end by means of heavy scissors. The capsule is examined for constrictions. The hour-glass contraction usually found between the femoral head and the acetabulum is divided. The capsule is forcibly dilated to expose the head of the femur. Sutures are placed in each side of the capsule in order to facilitate suturing when reduction has been made.

The joint cavity is explored with the index finger. The femoral head is usually found in a high posterior position. The teres ligament is located and will be found to lead to the old acetabulum. Any obstacle to reduction is overcome, the inferior capsule is cleared away from the acetabulum with a chisel, and all soft tissue is removed from the cavity. Occasionally it is necessary to sever the attachments of the pectineal muscles on the inner side of the femur. If the teres ligament is thickened, it should be excised.

Fig. 2. The hip in a plaster spica in abduction and inward rotation.

Reduction of the head is now obtained by a combination of abduction and internal rotation movements. A special instrument, the congenital hip skid devised by the writer (Fig. 1), is placed under the femoral head with its lip extending just inside the superior rim of the acetabulum. The operator pushes on the trochanter and at the same time lifts the skid to secure leverage, while an assistant brings the leg into abduction, strong inward rotation, and hyperextension. Considerable inversion is required to force the head into proper apposition with the acetabulum. When the femoral head reaches the cavity, it snaps into place. It is locked securely in position by further abduction and inward rotation of the head.

The capsule is overlapped, and the chromic gut sutures are tied securely. The muscles fall back into place, the operator using a catgut suture to prevent blind pockets. The fascia is closed with continuous chromic catgut and the skin with continuous catgut. A plaster spica is applied from the breast line to the ankle, with the hip in abduction and inward rotation, and with the knee flexed (Fig. 2).

Fig. 3. Case 1. Roentgenogram showing the femoral head in position after operation.

Fig. 4. Case 2. Roentgenogram showing the right femoral head in position nearly 12 years after open operation and the left femoral head in position nearly 11 years after manipulation.

The spica is worn for 8 weeks. At the end of this period, a new one is applied with the hip in 15 degrees to 20 degrees abduction and in marked inward rotation, with the knee extended. A plaster spica is used to maintain the hip in position for 6 to 10 weeks, depending upon the stability and the mechanical problem involved.

After-care. When the plaster spica has been removed, the hip, thigh, and calf should be massaged and put through passive movements daily. The patient should be taught to walk properly with the feet straight ahead to favor the return of muscle balance. Swimming is the ideal form of exercise.

Osteotomy of the femur. In an occasional case the internal rotation may be so marked as to require an osteotomy of the femur. This procedure is often necessary in cases of older patients. It should not be performed until motion in the hip is well established.

The technique of osteotomy of the femur is as follows. The femur is exposed through an incision 3 to 4 inches long, made just below the trochanter. A longitudinal incision about 1½ inches in length is made in the periosteum. A transverse osteotomy is done, and the lower part of the femur is rotated outward until the foot in recumbency points directly upward. The periosteum is sutured, and the wound closed in the usual manner. A plaster spica is applied and worn for 8 to 10 weeks. Weight-bearing is permitted during the latter part of this period.

Reconstruction operations. The object of a reconstruction operation is, first, to restore stability to the hip so that it can support the weight of the body without pain and, second, to preserve motion sufficient for ordinary movements.

Reconstruction operations are used in cases in which a permanent reduction cannot be insured because of the extreme hypermobility of the hip joint, due to the shallowness of the acetabulum or to the distortion of the femoral head. Reconstruction methods are also applicable to cases in which an attempt at reduction is useless, either because of the advanced age of the patient, or because of severe structural changes such as extreme alteration of the tissues, a great amount of shortening, or elevation of the hip. The best known methods of reconstruction are the bone-flap method of Albee (1), and the bifurcation method of Lorenz (38) and von Bayer (5).

Reinforcement of the acetabulum following reduction. The femoral head is reduced by the author's method. A curved shelf of bone, about 1½ inches wide and 4 or 5 inches long, is raised from the outer table of the ilium, behind and just above the femoral head. This bone flap is bent downward gradually until it projects outward at a right angle to the ilium. The shelf thus formed may be reinforced with a bone graft or chips of bone. This wedge acts as an obstacle to the recurrence of dislocation. The wound is closed and a plaster spica applied from the toes to the nipple line, with the leg abducted to about 30 degrees.

The formation of a new acetabulum in irreducible cases. This method may be used in cases in which an attempt at complete reduction would cause extensive trauma. Operators differ as to the selection of the site for the construction of the new acetabulum. Albee (1) forms a new socket on the ilium higher up than the original

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 5. Case 3. Roentgenogram showing dislocation of the right hip before operation.

Fig. 6. Case 3. Roentgenogram showing dislocation of the left hip before operation.

Fig. 7. Case 3. Roentgenogram showing the left hip in plaster after open reduction.

Fig. 8. Case 3. Roentgenogram showing the position of both hips after open reduction.

acetabulum. Gill (25) begins the new cavity at the site of the old acetabulum and continues the enlargement upward until the head can be placed in it. Balensweig (3) forms a new socket in the upper half of the old acetabulum. Speed (53) determines the level of the new cavity by bringing the femoral head into position by abducting the thigh, flexing it to about 60 degrees, and marking the place where the head rests on the ilium. A new socket is formed at this point.

The formation of a supporting shelf of bone without constru ting a new acetabulum in irreducible cases. The chief cause of pain and disability in irreducible cases is the lack of a bone support for the femoral head. The creation of a smooth gliding surface for the head, by the same technique as described under *The reinforcement of the acetabulum following reduction*, increases stability, relieves pain, and thereby improves function. This method is applicable particularly to adult cases.

The bifurcation method of Lorenz (38) and von Bayer (5) in irreducible cases. This procedure consists of an oblique osteotomy of the femur just below the trochanter, and the insertion of the proximal end of the lower fragment into the acetabular socket, where it rests against the femoral head. When properly done, this operation gives good results.

Arthrodesis. In adult cases in which there is instability, stiffness, pain, and deformity, arthrodesis is indicated to relieve the symptoms. A hip ankylosed in good position is preferable to one that is unstable and painful.

CASES OF REDUCTION

Case 1. B. C., aged 14 years, was first seen in February, 1921 The diagnosis of severe scoliosis, claw-feet, and dislocation of the left hip was made. The patient had suffered an attack of infantile paralysis at the age of 1½ years, but the dislocated hip was probably of congenital origin.

Treatment. In November, 1921, an attempt was made to reduce the hip by manipulation, but it was not successful. On December 8, 1921, an open reduction was performed. This was followed, on February 9, 1922, by an osteotomy of the femur. On August 24, 1922, the hip was manipulated under ether.

Result. In June, 1923, the head was stable. There was motion in flexion to 30 degrees and internal rotation of 10 degrees. External rotation was normal. Function was increased in spite of the existing scoliosis. April 22, 1927, 6 years after the operation, the patient walked with the hip stable. There was motion in flexion to 90 degrees, and internal rotation was about one-half normal. External rotation was normal (Fig. 3).

Case 2. M. G., aged 9 years, was seen in November, 1915, and a diagnosis of congenital dislocation of both hips was made.

Treatment. November, 1915. An open operation was performed on the right hip. The patient then wore a plaster spica for nearly a year. In November, 1916, the left hip was manipulated.

Result. July, 1923. The right hip was in good position. There was flexion of 60 degrees and good adduction, abduction, and internal rotation. The patient walked without a limp. The left hip had flexion of 60 degrees and normal abduction and adduction. June 18, 1927, nearly 12 years after the operation, the right hip had flexion of 85 degrees; both internal and external rotation were excellent. The left hip had flexion of 115 degrees and normal abduction and adduction (Fig. 4).

Case 3. A. S., aged 5 years, was first seen in September, 1920. This patient walked with a double hip limp. The left leg was rotated externally 30 degrees and the right leg 25 degrees. Roentgenograms (Figs. 5 and 6) show both femoral heads out of the acetabular sockets.

Treatment. One year previous to examination by the writer, the hips had been manipulated. In October, 1920, an open reduction of the left hip was done by the writer (Fig. 7). One year later the right hip was reduced by the open method.

Result. In July, 1923, both hips had flexion of 90 degrees, abduction of 35 degrees, and hyperextension of 10 degrees. Function was greatly improved, and the child walked without a limp. On April 27, 1927, the hips had flexion to 115 degrees and abduction of 15 degrees. A roentgenogram (Fig. 8) showed the hips to be in good position.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 9. Case 4. Roentgenogram showing dislocation of the left hip before operation.
Fig. 10. Case 4. Roentgenogram showing the hip in plaster after open reduction.
Fig. 11. Case 4. Roentgenogram showing the hip in position after open reduction.

CASE 4. L. D., aged 4 years, was first seen in July, 1920, and a diagnosis of congenital dislocation of the left hip was made (Fig. 9).

Treatment. An open operation was performed according to the usual technique (Fig. 10).

Result. In September, 1920, the head of the femur was in good position. There was no shortening. In March, 1921, the patient could flex his hip to a right angle. In July, 1923, 3 years after the operation, the patient walked without a limp. Flexion, extension, abduction, and inward rotation were normal. The result was considered perfect (Fig. 11).

CASE 5. E. H., aged 2 years and 10 months, was first seen on April 17, 1923. This child walked with a distinct waddle, characteristic of double congenital dislocation of the hip (Fig. 12).

Treatment. On June 12, 1923, an open operation was performed on the left hip according to the usual technique. The neck of the femur was found twisted and the head was flat. Reduction was accomplished with difficulty. A plaster spica was applied with the leg in the position of abduction, internal rotation, and hyperextension (Fig. 13). On July 10, 1923, a new spica was applied with the internal rotation and abduction reduced one-half. The spica was removed on September 4, 1923. At that time the hip had 15 degrees abduction and rotation was free. The leg was in slight rotation, necessitating a manipulation into abduction. Massage of the thigh and calf was advised. On March 18, 1924, the right hip was manipulated under ether and reduction effected. A plaster spica was applied with the legs in a frog position. On July 8, 1924, a new spica was applied with the legs in the same position. On September 2, the plaster spica was removed and a flannel one applied. On March 17, 1925, the right hip was manipulated into extreme abduction, and a spica applied. This spica was removed on September 1, 1925.

Result. On September 29, 1925, the right hip was in good position and had motion from 35 degrees to 40 degrees. The left hip had flexion to 80 degrees, and rotation was good. On January 19, 1926, the right hip had 85 degrees to 90 degrees flexion and a few degrees rotation. The left hip had 120 degrees flexion and a few degrees rotation. Both hips were in position (Fig. 14). On April 12, 1927, nearly 4 years after the open reduction of the left hip, all motions were normal. Both extremities were of equal length. The result was excellent.

CASE 6. H. S., aged 5 years, was first seen on May 15, 1923. This child walked with a dip of the right hip. Flexion was normal, but abduction was limited. A roentgenogram (Fig. 15) showed a high posterior dislocation.

Treatment. On June 12, 1923, an open reduction was accomplished with difficulty. The inferior capsule was found to be adherent to a shallow acetabulum. A plaster spica was applied from the ribs to the ankle, with the leg abducted, rotated internally, and hyperextended (Fig. 16). The spica was changed on July 10, 1923. When this was removed on September 4, 1923, the hip went easily into 15 degrees abduction. Internal rotation was possible to a few degrees. Forcible abduction and massage were to be continued.

Result. On January 22, 1924, the child was walking. She had about 80 degrees motion in flexion and good rotation. On June 10, 1924, motion in flexion was increased to 90 degrees. Rotation was good. There was shortening of $\frac{3}{8}$ of an inch. The patient walked with only a slight limp (Fig. 17). On April 12, 1927, nearly 4 years after reduction, the hip could be flexed to a right angle. Rotation was about two-thirds normal. Abduction was almost complete. There was about ½ inch shortening, which probably will be compensated for before adult life. The result was excellent.

CASE 7. S. G., aged 9 years, was first seen in October, 1923. This child walked with a limp of the right leg. A roentgenogram (Fig. 18) showed the trochanter to be high and posterior.

Treatment. On December 11, 1923, an open operation was performed according to the usual technique. It was necessary to rotate the thigh 90 degrees in order to face the head into the acetabulum.

Result. On February 6, 1924, the spica was removed. The hip had 30 degrees to 40 degrees motion in flexion and free abduction and adduction. On March 8, 1924, the hip was in place. The child had about 25 degrees motion without pain, and could abduct the hip. On April 3, the hip had 40 degrees flexion and good motion in abduction and adduction. On September 16, 1924, the child walked with a slight limp. Manipulations were advised. A roentgenogram (Fig. 19) showed the hip to be in excellent position.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 12. Case 5. Roentgenogram showing dislocation of both hips before operation.

Fig. 13. Case 5. Roentgenogram showing the position of the left hip in plaster after open reduction.

Fig. 14. Case 5. Roentgenogram showing the position of the left hip after open reduction.

The prognosis of the case was most favorable. It has been impossible to obtain further information on this case.

CASE 8. F. M., aged 9 years, was first seen in May, 1921. This child walked with a double hip limp. The right hip had been operated by the open method in an out-of-town clinic, but the result had not been successful.

Treatment. On May 17, 1921, the right hip was reduced by open operation. Reduction was accomplished with difficulty. The capsule was so thick that it required great care to turn it away to expose the acetabulum. The head and acetabulum were extremely deformed.

Result. Two years after operation, the hip was stable. Flexion of 30 degrees to 40 degrees, adduction and abduction of 10 degrees, and slight internal and external rotation were possible. On March 26, 1925, nearly 4 years after operation, the patient had 80 degrees flexion, 10 degrees abduction, adduction, and complete extension. Roentgenogram (Fig. 20) shows the femoral head in position.

CASE 9. F. G., aged 9 years, was first seen in May, 1917, and a diagnosis of congenital dislocation of the right hip was made. The right leg was about 1½ inches shorter than the left.

Treatment. On May 28, 1917, an open reduction was made.

Result. Ten years after operation, flexion, extension, hyperextension, adduction, and external rotation were normal. Abduction and internal rotation were one-half normal. The limitation in the range of abduction appeared to be due to tension of the adductor muscle group rather than to any bony block in the hip joint region. The limitation in rotation was not painful. The gait was normal. The result was excellent (Fig. 21).

CASE 10. S. Z., aged 9 years, was seen first in April, 1922, and at that time the diagnosis of congenital dislocation of the left hip was made (Fig. 22).

Treatment. In August, 1922, an open operation was performed according to the usual technique.

Result. In August, 1927, 5 years after the operation, the patient walked with a limp referable to the left hip. The left hip and knee were held rigid, and the weight was borne on the fore part of the foot. Flexion from 10 degrees to 15 degrees, without pain, was possible. There was no abduction nor adduction. The patient walked better than before operation and she was free from pain. The femoral head was in place, as shown in the roentgenogram (Fig. 23).

CASE 11. I. K., aged 7 years, was first seen on January 19, 1926. She walked with a dip of the left hip, characteristic of congenital dislocation. The trochanter was felt high above Nelaton's line. Right anterior 23½ inches; Left anterior 22 inches (Fig. 24).

Treatment. March 16, 1926, a manipulation under ether was performed and traction applied. It was not successful. On May 11, 1926, an open reduction was performed. On February 15, 1927, the hip was manipulated into abduction. At that time the hip had about 20 degrees abduction and a few degrees of flexion.

Result. On June 21, the hip had 10 degrees abduction, slight external rotation, and 20 degrees flexion. In September, 1 year and 4 months after reduction, the hip had 45 degrees flexion and 15 degrees abduction. Rotation was limited (Fig. 25).

CASE 12. E. W., aged 5 years, was first seen on September 13, 1927. Examination showed that the right hip was dislocated high and posteriorly. It was adducted and rotated internally (Fig. 26).

Treatment. On November 8, 1927, an attempt to reduce the hip by manipulation was unsuccessful. On November 22, 1927, an open reduction was performed. A roentgenogram (Fig. 27) showed the hip in plaster in perfect position.

Result. At the end of 3 months the plaster was changed and new plaster applied with less abduction. The patient was to begin weight-bearing. Roentgenogram showed the hip in good position. Figures 28 and 29 show the alignment of the limb after removal of the plaster. Some motion was present. This patient is still under observation and is improving steadily.

HISTORICAL SKETCH OF THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP

The first careful study of congenital dislocation of the hip was published by Schreger (50) in 1818. At that time the disease was considered incurable, an opinion that was chiefly due to the failure of surgeons to recognize the affliction until secondary deformities were marked. Then, too, owing to the fact that the primary lesion was believed to lie in the defect or in the lack of development of the acetabulum, any form of treatment devised to meet such a condition could not effect reduction.

Fig. 15

Fig. 16

Fig. 17

Fig. 15. Case 6. Roentgenogram showing dislocation of the right hip before operation.
Fig. 16. Case 6. Roentgenogram showing the hip in plaster after open reduction.
Fig. 17. Case 6. Roentgenogram showing the right hip in position after open reduction.

Among the early methods of treatment were: manipulation of the hip into extension in an attempt to draw the femur into position (Dupuytren, 19); subcutaneous operations, with or without manipulation of the hip into extension (Bouvier, 7; Pravaz, 46; Corridge, 15; and Brodhurst, 10); tenotomy of the peritrochanteric muscles (Guérin, 26; Barwell, 4); resection of the femoral head (Roser, 49; Reyher, 47); formation of a new acetabulum (Koenig, 31; Tubby, 55; Margary, 41; Poggi, 45; Ogston, 42); and fixation of the femoral head to the iliac bone by means of nails (Witzel, 58) or ivory pegs (Kirmisson, 30). All of these methods are only of historical interest. In general, they yielded unsatisfactory results.

In 1890, Hoffa (28) brought forward the first procedure that offered a possibility of relief. In brief, his method was as follows: The capsule was exposed by an oblique incision, made along the posterior border of the greater trochanter between the tensor vaginæ femoris and the gluteus medius. In the early application of his method, Hoffa severed all the muscles attached to the greater and lesser trochanters, but later he revised his technique to avoid this step. The acetabulum was deepened in forward and upward directions with large spoon curettes. The femoral head was replaced. A plaster spica was applied with the leg in slight abduction. In some instances Hoffa performed tenotomy of the hamstring tendons and divided the fascia about the ilium.

Lorenz (39) modified Hoffa's technique, making an incision on the anterior external surface and sparing the muscles. From 1892 to 1896, Lorenz performed 232 open reductions. Good results were obtained in but few cases. In general the mortality was so high, owing to loss of blood and sepsis, that Lorenz finally abandoned the method.

While attempts were being made to obtain reduction by open intervention, a number of surgeons, in particular French orthopedists, were experimenting with various closed manipulative processes and mechanical appliances. Through the efforts of Pravaz (46), Paci (43), and Lorenz (39), a bloodless manipulative process was worked out. Between 1895 and 1904, this method became recognized as the routine treatment of congenital dislocation.

Open interference, however, was not entirely abandoned. All surgeons, among whom were even the strongest advocates of the bloodless operation, agreed that it was necessary to resort to open intervention in cases of marked displacement with a constricted capsule, and in long-standing cases. Several orthopedists, realizing the great danger of traumatism in manipulative handling, urged a more extensive use of the open procedure. Sherman (51), in a presentation before the American Orthopedic Association in 1904, pointed out in detail the traumatic danger which the manipulative treatment entails, and called attention to the impossibility of securing reduction by this method in cases in which the capsule is narrowed. In 28 cases which Sherman explored, he found only one in which the

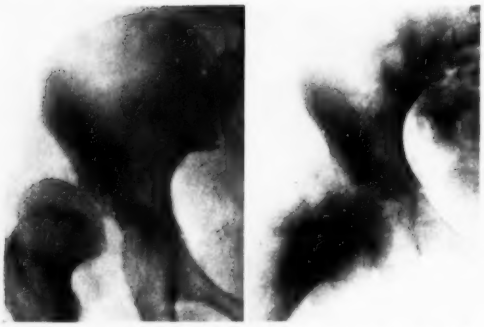

Fig. 18 (left). Case 7. Roentgenogram showing the dislocation of the right hip before operation.

Fig. 19. Case 7. Roentgenogram showing the right hip in position after open reduction.

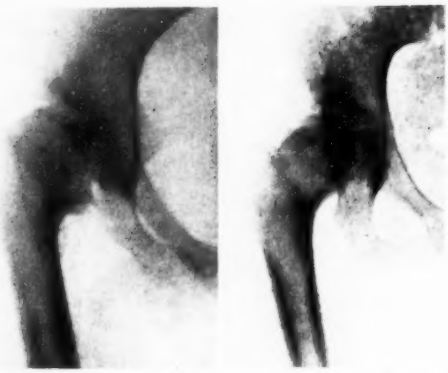

Fig. 20 (left). Case 8. Roentgenogram showing femoral head in position.

Fig. 21. Case 9. Roentgenogram showing the right hip in position after open reduction.

narrow part of the capsule was of sufficient width to allow the passage of the femoral head.

Sherman's (52) technique is as follows: An incision is made from the anterior superior iliac spine downward, just external to the long head of the rectus femoris. The capsule is incised freely in line with the incision already made. The hip is flexed. A long-bladed bistoury is guided by the gloved finger into the acetabulum. The capsule is cut downward by pushing the finger against the blade inside the capsule and moving the handle of the bistoury to and fro with the hand. The operator can then slide his finger along the knife into the acetabulum. The head is placed in the socket. The thigh is extended, abducted to approximately 75 degrees, and rotated inward to 90 degrees. The knee is flexed. When the hip and knee are in these positions, the long head of the rectus is tight and, lying as it does directly over the femoral neck, anterior luxation is prevented. The capsule on the inner side of the incision is not sutured, but is carried downward and inward with the neck as it moves with the head into the acetabulum. The fascia lata is sutured with catgut, and the skin with horsehair. A plaster-of-Paris splint is applied and worn for 4 to 6 weeks. If necessary, an osteotomy may be performed to fit the component parts.

Sherman reduced 58 cases by this method; in 29 of these cases, reductions alone were performed, and in the other cases supplementary osteotomies were done. Twelve of the first group obtained functionally normal joints, 8 have gone into anterior transposition, 3 have stable reposition, and 1 has become ankylosed. In the other group, in which reduction was

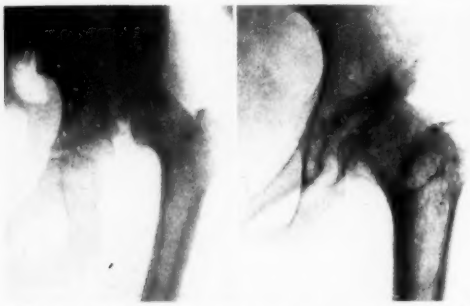

Fig. 22 (left). Case 10. Roentgenogram showing dislocation of the left hip before operation.

Fig. 23. Case 10. Roentgenogram showing the left hip in position after open reduction.

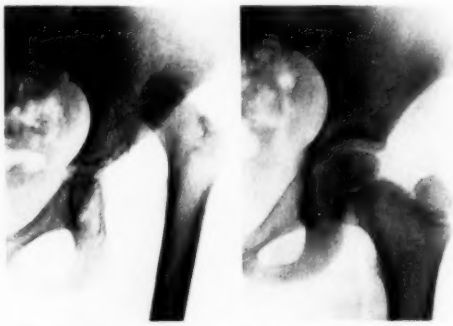

Fig. 24 (left). Case 11. Roentgenogram showing dislocation of the left hip.

Fig. 25. Case 11. Roentgenogram showing the left hip in position after open reduction.

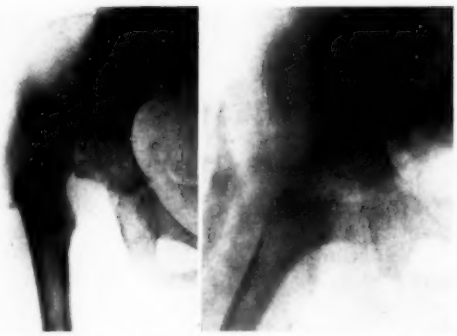

Fig. 26 (left). Case 12. Roentgenogram showing dislocation of the right hip before operation.

Fig. 27. Case 12. Roentgenogram showing the right hip in plaster following open reduction.

Fig. 28. Case 12. Photograph showing alignment of limb after removal of plaster.

followed by osteotomy, 70.3 per cent successful results were obtained.

In 1920, Galloway (23), following in the path outlined by Sherman, began to use open interference in selected cases. His success with the method led to his resorting to open operation in all cases. Galloway considered that the best ages for open reduction were from 20 months to 2 years. His method is as follows: The capsule is exposed by the Smith-Petersen incision. The limb is rotated inward, and the capsule opened by a crucial incision. The limb is then rotated outward, exposing the teres ligament. This will be found to lead to the acetabulum. Any constriction of the capsule is freely divided. If the acetabulum is filled with fibrous tissue, as usually occurs in children over 3 years of age and not infrequently even in younger patients, the mass is carefully stripped from the roof and walls of the cavity and pushed toward the floor. The head is reduced, the hip skid being used if necessary. The wound is sutured in layers. The capsule is not sutured. A plaster spica is applied with the hip in the position of abduction. Three weeks after application, the spica is changed and weight-bearing encouraged. The plaster bandages are changed at 6 to 8 week intervals, and at each change the abduction is reduced.

During the 6 years from 1920 to 1926, Galloway (24) operated on 38 cases, using various methods, including the reduction method already described, arthrodesis, reinforcement of the acetabulum, and the formation of a new socket. Nine were cases of bilateral dislocation. Fifteen results were excellent; 18 were good; and 5, although doubtful, were not failures. It is an interesting feature that, with one exception, the patients who were cured were between 17 months and 2½ years of age, while those who obtained good results were between 3 years 9 months and 29 years.

Many different methods of reduction have been devised. Ingianni (29), Ricard (48), Corner (14), Frisch (22), Lambotte (34), Lexer (37), Tubby (55), LeDamany (35), Thomas (54), Patschke (44), Ludloff (40), Fairbank (20), Davis (16), Allison and Dixon (2), Willis (57), Berstein (6), Clarke (12), Bradford (8), and Burghard (11) have reported cases of open operation. One of the largest groups of cases, comprising 35, was reported by Deutschlaender (17), in 1922. Deutschlaender called particular attention to the necessity of relaxing the iliopsoas, for only when this muscle is at rest is it

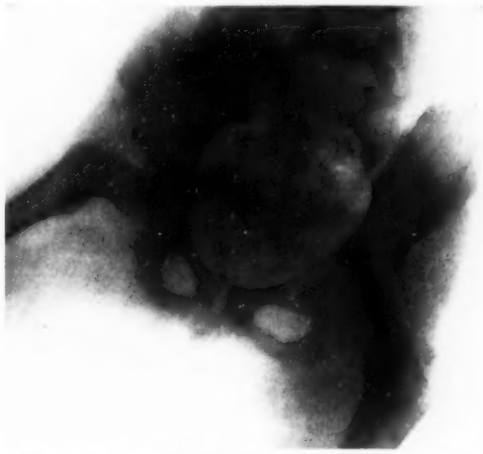

Fig. 29. Case 12. Roentgenogram taken after removal of plaster.

possible to gain entrance to the head of the femur. Thirty of the reductions resulted in both anatomical and functional improvement.

In cases in which reduction was impossible, operators have used the bifurcation method, the bone-flap method, and the process of constructing a new acetabulum—procedures that have been mentioned under the discussion on treatment. Lorenz (38) used the bifurcation method in 60 cases with excellent results. Some of the patients showed no signs of crippling and could run and jump. This operation has the advantage of relieving deformity, even though the result as to function is not entirely satisfactory. Kortzeborn (32) secured most gratifying results in 2 cases operated by this method.

Among those using the bone-flap method is Dickson (18), who applied it in 5 cases of old dislocation. The disability in the cases consisted of (1) a short limb; (2) an unstable joint, and (3) abnormal posture. Four cases resulted satisfactorily with a gain in motion and a decrease of the shortening. In the fifth case, infection gave rise to limitation of motion.

Fairbank (20) reported a group of 11 cases in which he formed a new acetabulum by turning down a periosteal flap from the ilium over the upper margin of the acetabulum. In 3 cases the results were satisfactory; in 4, there was anterior reposition; in 1, arthritis developed, and 1 case relapsed. It was impossible to obtain information on the other cases.

Speed (53) reported 8 cases in which a new acetabulum was formed on the lateral surface of the ilium. His results were disappointing; stability was good, but motion was restricted. Adduction contractures developed in 3 cases. Limp persisted in several cases.

The construction of a new acetabulum in the vicinity of the normal cavity was tried by several operators, including Codivilla (13), LeFort (36), Krause (33), Burghard (11), and Davis (16).

CONCLUSIONS

The open operation, which affords the opportunity to study the pathology and which involves much less danger than forcible manipulative and mechanical procedures, may be used to advantage more often than is the customary practice. Examination of the pathological changes often reveal an hour-glass shaped constriction of the capsule, or marked anteversion of the femoral neck, or an acetabulum filled with adherent tissue covered over with the inferior capsule. In the presence of such alterations, the closed method is futile.

Operative interference is indicated in children from 4 to 8 years of age, when one or two closed manipulations have failed. In older children it is the method of choice, and in adults it is indicated to correct deformity and relieve arthritic symptoms.

Simple replacement of the head within the socket is the ideal method of treatment. If age or extensive pathological changes exclude the use of this method, reconstruction operations may produce results which are functionally and anatomically satisfactory.

BIBLIOGRAPHY

1. Albee. J. Am. M. Ass., 1925, lxxxv, 1345.
2. Allison and Dixon. Interstate M. J., 1917, xxiv, 161.
3. Balensweig. J. Bone & Joint Surg., 1926, viii, 534.
4. Barwell. A Treatise on Diseases of Joints. London, 1861.
5. Bayer, von. Ztschr. f. orthop. Chir., 1924, xliv, 591.
6. Berstein. J. Bone & Joint Surg., 1922, iv, 481.
7. Bouvier. Mémoire sur la réduction des luxations congénitales du femur. Paris, 1838.
8. Bradford. Surg., Gynec. & Obst., 1906, iii, 247.
9. Idem. Am. J. Orthop. Surg., 1905-06, iii 171.
10. Brodhurst. St. George Hosp. Rep., London, 1866, i, 217.
11. Burghard. A Manual of Surgical Treatment. 1900, ii, 129.
12. Clarke. Tr. Internat. Cong. Med., 1913-14, vii, 25.
13. Codivilla. Zentralbl. f. chir. u. mech. Orthop., 1907, i, 289.
14. Corner. Med. Press & Circ., 1913, xcvi, 698.
15. Corridge. Reported by Jones, J. P. Med. & Surg. Rep. Episc. Hosp., Philadelphia, 1914, ii, 261.
16. Davis. Am. J. M. Sc., 1909, cxxxvii, 37.
17. Deutchlaender. Deutsche med. Wchnschr., 1922, xlviii, 1476.
18. Dickson. J. Bone & Joint Surg., 1924, vi, 262.
19. Dupuytren. On the Injuries and Diseases of Bones. London, 1847.
20. Fairbank. Lancet, 1908, i, 1752.
21. Idem. Proc. Roy. Soc. Med., 1923, xvi, 15.
22. Frisch. Wien. klin. Wchnschr., 1919, xxxii, 1192.
23. Galloway. J. Orthop. Surg., 1920, ii, 390.
24. Idem. J. Bone & Joint. Surg., 1926, viii, 539.
25. Gill. Surg. Clin. N. Am., 1926, vi, 147.
26. Guérin. Gaz. de med.-prat., 1840, ii, 28.
27. Idem. Recherches sur les luxation congénitales, 1841.
28. Hoffa. Verhandl. d. deutsch. Gesellsch. f. Chir., 1890, ii, 44.
29. Ingianni. Policlin, 1905, xii, sez. prat., 669.
30. Kirmisson. Rev. d'orthop., 1906, vii, 265
31. Koenig. Ztschr. f. Chir., 1891, xvii, 146.
32. Kortzeborn. Beitr. z. klin. Chir., 1924, cxxxi, 664.
33. Krause. Reported by Deutschlaender. Deutsche med. Wchnschr., 1922, xlviii, 1476.
34. Lambotte. Arch. franco-belges de chir., 1921, xxv, 244.
35. Le Damany. Rev. de chir., 1903, xxviii, 708.
36. Le Fort. Soc. de chir. de Par., 1910, xxxvi, 810.
37. Lexer. Deutsche Ztschr. f. Chir., 1916, cxxxv, 389.
38. Lorenz. Nedrl. Tijdschr. v. Geneesk, 1923, i, 2207.
39. Idem. Heilung der angeboren Hueftgelenk Verrenkung. Leipzig and Vienna, 1900.
40. Ludloff. Am. J. Orthop. Surg., 1912-13, x, 438.
41. Margary. Arch. di ortop., 1884, i, 381.

42. Ogston. Brit. M. J., 1885, ii, 1116.
43. Paci. Arch. di ortop., 1896, xiii, 305.
44. Patschike. Deutsche med. Wchnschr., 1911, xxxvii, 1689.
45. Poggi. Arch. di ortop., 1890, vii, 105.
46. Pravaz. Traité théorique et des luxations congénitales du femur. Lyon, 1847.
47. Reyher. Zentralbl. f. Chir., 1884, xi, 232.
48. Ricard. Bull. et mém. Soc. de chir. de Par., 1910, xxxvi, 582.
49. Roser. Verhandl. d. Gesellsch. f. Chir., 1879, viii, 46.
50. Schreger. Reported by Jones, I. P., Med. & Surg. Rep. Episcopal Hospital. Philadelphia, 1914, xi, 261.
51. Shirman. J. Am. M. Ass., 1905, lxvi, 31.
52. Idem. Surg., Gynec. & Obst., 1914, lxii, 18.
53. Speed. J. Am. M. Ass., 1926, lxxxvii, 1631.
54. Thomas. J. Am. M. Ass.,-1922, lxxviii, 323.
55. Tubby. Deformities. London, 1912.
56. Idem. Med. Press & Circ., 1910, lxxxix, 675.
57. Willis. Northwest Med., 1907, v, 380.
58. Witzel. Zentralbl. f. Chir., 1901, xxviii, 977.

A FURTHER STUDY OF CLEFT PALATE[1]

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In the early part of 1927, a clinical study of what was considered to be a new method for the treatment of cleft palate was described in the *Canadian Medical Association Journal*. This study of cleft palate was based on the development of the superior maxillary bone.

At birth and during infancy the measurement of the superior maxilla is greater in the anteroposterior direction than in the vertical direction. In adults the vertical measurement is greater. In studying cleft palate one is impressed with the fact that this deformity is not due to lack of development but rather to lack of fusion of the component parts of the superior maxillary bone.

Sir Arthur Keith has said that in the majority of cases of complete cleft palate there is no deficiency of tissue at birth nor for some time after birth, and that he also agrees that the cleft, however wide, is not due to a deficiency of tissue in the several elements which form the palate, but is entirely due to the fact that when the various embryonal parts or elements are developed and come together in the second month of development, the process of union, which should occur then by a means similar to union by first intention, is delayed and does not take place, hence the several palatal elements, being inco-ordinated by union, tend to separate as growth occurs, and the cleft increases during each month of growth.

The aim of those who would treat cleft palate by the method to be described presently is to remold the upper jaw so that its vertical dimension is increased at the expense of the anteroposterior and lateral dimensions.

Let us examine the roof of the mouth with its hard and soft palates. Included in the former are the maxillæ and premaxillæ and the alveolar processes of these bones. The roof of the mouth may be pictured as a horseshoe. We note that, in a desire to close the cleft of the palate, it will be advisable to approximate the lateral parts of this horseshoe without causing too great protrusion forward of the anterior parts represented principally by the premaxillæ and also by the anterior cornua of the superior maxillæ.

We must aim to stimulate the normal development of the superior maxillary bone by increasing the vertical measurement of the upper jaw as opposed to the anteroposterior measurement. This we feel can be done.

The object. In planning our *modus operandi* we must bear in mind the importance of the fact that our object is not only to make lateral pressure to close the cleft, but to regulate this lateral pressure, because such lateral pressure might force the premaxillæ and adjacent parts too far forward.[1]

Our aim is to reduce the transverse and anteroposterior dimensions of the roof of the mouth by heaping up the tissues in front and on the sides in much the same way as a farrier remodels a horseshoe by hammering every section of red hot metal in order to reduce its size and increase its strength by changing its form.[2]

To do this, pressure must be exerted on the outer surface of both maxillary and premaxillary alveolar processes. No part must be left unguarded. Pressure is made by the application of plates of German silver molded to conform to the outer and anterior aspects of the alveolar arch. Pres-

[1] It is to be noted that normally the upper incisor teeth overlap the lower incisors in an anterior position. Approximation of the soft parts anteriorly makes the posterior part of the cleft still wider and, conversely, the bringing together of the posterior part of the cleft palate will tend to spring the anterior part and make it wider, and lateral pressure without anterior pressure, will cause a protrusion forward of the premaxillæ.

[2] When a farrier reduces the size of a horseshoe by heaping up the red hot metal he is said to be "jumping up" the metal.

[1] Carried out in The Children's Memorial and Shriners' Hospitals, Montreal. Read in part at the meeting of the Medico-Chirurgical Society of Montreal, May 4, 1928.

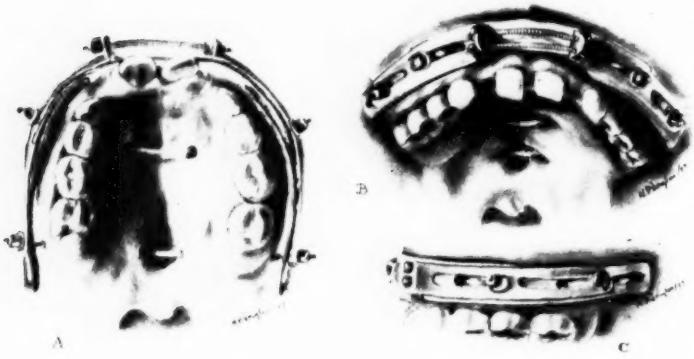

Fig. 1. *A*, left. Roof of mouth. Note the anterior silver plate interposed between the lateral silver plates, the latter being somewhat superimposed on lead plates which are used as a cushion to protect the gums. The lateral plates are so fashioned that threaded wires can be carried through them in order to regulate the pressure made on the alveolar process. *B*. Note the lateral plates covering the anterior plate. The anterior extremities of these lateral plates are bent at right angles. *C*. Lateral view. Note the position of the posterior wire above and behind the last molar. The slots allow for movement of plates as the pressure is regulated by the traction wires and nuts.

sure is exerted on these plates by means of threaded wires which are carried transversely through and across the palatal arch, through the alveolar processes on either side again to pass through the perforated (slotted) silver plate on either side. The plates are fitted to these wires by means of small nuts which are used to regulate the pressure brought to bear on the silver plates. As the plates are fairly rigid, this pressure is distributed evenly throughout their length.

The wires. The first step in the operation for the relief of cleft palate by this method is to introduce two transverse wires from the alveolar process of one side to the alveolar process of the other side. This we do with difficulty. We try to place these wires as high as we are able; in younger patients if possible, above the hard palate. We must not interfere either with the erupted or unerupted teeth. We endeavor to insert these wires in positions most advantageous to exert pressure by traction in order to modify growth and deformity. The posterior transverse wire must be placed as far posterior as possible and the anterior transverse wire must be placed not too far from the anterior extremities of the superior maxillæ.

The plates. The second step in this method is the insertion of the three plates used for the compression of the palate. The anterior plate exerts pressure on the anterior part of the arch and is fashioned so as to cover the anterior surface of the premaxillary and the anterior surface of the maxillary alveolar processes. A slot is cut in the long axis of this plate so that it may be maintained in position on the transverse wires already described and so that it may be forced in a posterior direction by traction on the lateral plates.

The two lateral plates are fashioned to cover the external surface of the maxillary alveolar processes. These are very much the same size as the lead plates at one time used by Brophy for a somewhat similar purpose. The anterior extremity of each of these plates extends forward to about the position of the lateral incisor tooth on each side and is turned outward at a right angle to the plane of the plate. This out-turned extremity is perforated for two traction wires fitted with nuts which are used to connect the outturned extremities of these two lateral plates. A slot is cut in the long axis of each of these plates so that these plates also, may be maintained in position by the anterior transverse wires already described and yet be freely movable in an anterior direction. These lateral plates are perforated posteriorly for insertion into the posterior transverse wires, which anchor these plates. No movement is possible at the point of insertion of the posterior transverse wires into this perforation, as the plates are fixed to the posterior transverse wires with two small threaded nuts.

These three plates may be fashioned on a dentist's plaster cast of the alveolar processes and roof of the mouth. These plates are made of a hard metal such as German silver, but if advis-

able, lead plates of a similar size may be inserted underneath these rigid plates for the purpose of protecting the gums.

Anteroposterior compression. After the three plates are in position, two threaded wires are inserted between the out-turned extremities of the lateral plates, the latter being superimposed on the anterior plate. These threaded wires are for the purpose of traction and are fixed in position by nuts. It will be seen that these wires connect the anterior out-turned extremities of the lateral plates and thus maintain these plates in position. The lateral plates can by this connection well control the anteroposterior pressure exerted by the anterior plate through traction on the lateral plates. This traction is made by the nuts which maintain these two anterior traction wires in position. These nuts regulate the compression made on the palate.

It will be seen, now, that if traction be made on the two lateral plates by tightening the two traction wires, pressure by traction will force the anterior plate backward and bring the posterior and lateral surfaces of the alveolar processes forward so that the whole superior maxilla will be compressed by pressure exerted in all directions over the external surface of the alveolar processes. The backward sliding of the anterior plate is made possible by the fact that this and the lateral plates have been fashioned with slots into which the anterior threaded wires fit. The arrangement of the slots on the anterior plate and the two lateral plates are complementary to each other. The anterior transverse wire fits into both of these and maintains the level of these plates on the outer surfaces of the alveolar processes. Pressure in a posterior direction as well as traction in an anterior direction is assured by tightening the anterior or traction wires. As the anterior plate is carried backward and as pressure is exerted on the lateral plates by tightening the nuts on the transverse wires, the alveolar processes of the maxillæ and premaxillæ will be remolded in such a way that both the internal and the external architecture will be changed and growth must of necessity be in a vertical direction, viz., from below upward instead of in an anteroposterior direction.

The extraordinary power exerted by this apparatus has been proved by test. It is a power which must be used wisely. Whether it is best to attempt immediate or forcible correction, or rather the gradual correction of the orthodontist, will depend largely on the character of the deformity and the age of the patient.

The future changes in the architecture of the alveolar processes and the influence exerted on the eruption of the teeth are not fully known.

Whether this method will be found useful in other conditions such as fractures and "orthodontic" affections is open to question. Yet we feel that this study of cleft palate has been worth while, because a method has been evolved which has already manifested its usefulness in certain cases.

In some cases modifications in the technique have been made so as to meet special conditions.

NOTE.—In this study I have been but the directing spirit. A group composed of Doctors H. R. Derome, A. D. Angus, C. M. Kirk, and R. Breitman have all contributed. The splints or plates which we use are made in a machine most ingeniously planned by Mr. R. Frank Girdwood of Montreal and made available for our use by those who have contributed to the All Masons Fund of the Province of Quebec.

ENDOMETRIAL ADENOMATA IN ABDOMINAL SCAR FOLLOWING CÆSAREAN SECTION

By WILLIAM J. GERMAN, M.D., Boston
From the Surgical Service of the Peter Bent Brigham Hospital

ADENOMATA of endometrial type occur in adult females and may be located within the abdomen or in its walls, but never above the level of the umbilicus. The diversity of the sites in which they have been found is perhaps approached only by the number of theories of their origin.

Embryonic theory. As early as 1893, von Recklinghausen (35) discussed the subject of endometrial adenomata and suggested that they might arise from embryonic rests derived from the wolffian body. Bits of this body have been described near the site for the inguinal canal in the embryo. This theory might therefore account for the endometrial adenomata of the round ligament, but it would be difficult to attribute to the wolffian body, occupying a dorsal position in the embryo, the production of endometrial tumors in the anterior abdominal wall of the adult.

Cullen (8) in 1914 suggested the possibility of remnants of Mueller's ducts as a point of origin. Again, it would be difficult to account for endometrial tumors of the abdominal wall or the umbilicus on such a basis, although it might be applicable to those of the rectovaginal septum or the broad ligament.

Peritoneal theory. Lockyer (17) in 1918 reported 47 cases of adenomyomata with endometrial glands, in the rectovaginal septum and thought that the peritoneum or vagina was the source of the epithelium in most of these cases. Robert Meyer (20) believed them to be of inflammatory origin. Recently, Nicholson (21), in a review of these tumors in laparotomy scars, upheld the peritoneal theory.

Displacement theory. Cullen (6) in 1897 suggested that the adenomyomata of the uterus with glands of endometrial type were due to the invasion of the uterine wall by its mucous membrane. In 1921, Sampson (26) reported his first 23 cases of endometrial tissue in hæmorrhagic cysts of the ovary, which he held to be due to the implantation of endometrium escaping from the open ends of the fallopian tubes. Since that time an attempt has been made to account for most of the endometrial tumors on the implantation basis. Bonney (3) described a case in which endometrial tissue was accidentally implanted in the abdominal scar during a hysterotomy with curettage. A typical endometrioma developed in the scar and was excised two years later.

Adenomyomata of the round ligament, containing endometrial glands and stroma, have been reported by Martin (19), von Recklinghausen (36), Cullen (5), Pfannenstiel (23), Blumer (2), Weber (37), and Semmelink and de Josselin de Jong (33). Similar growths in the ovarian ligament have been reported (7). Lockyer (17) collected 47 cases occurring in the rectovaginal wall.

Cullen (5) reported an adenomyoma of the endometrial type occurring in the labium majus, appearing 7 years after an instrumental delivery and becoming swollen and painful during menstruation. A similar growth was reported by von Recklinghausen (36) and one more recently by Henry (15).

Green (13) reported an adenoma of the umbilicus, containing glandular elements of uterine character. Cullen (9) collected 11 such cases and Weller (38) has recently reported 2 more.

Russell (25) demonstrated the presence of endometrial tissue in the ovary in 1899. This was confirmed by Casler (4), Cullen (10) and Norris (22). Since 1921 Sampson (26, 28) has reported many such cases. Endometrial adenomata have been found in many locations in the abdominal cavity, including the appendix (32).

The cases of adenomata of endometrial type, occurring in laparotomy scars, have been reviewed by Lemon and Mahle (16), Nicholson (21), and Pratt (24). The latter reviewed 46 cases up to 1926 and found that the age of occurrence varied from 20 to 46, with an average of about 35 years. Pain in the scar during menstruation was the most constant symptom and was present in 55 per cent of the cases. In 10 cases there was a definite connection between the tumor and the uterus. Local excision was sufficient to remove the growth in all but 2 cases, but in these a second complete excision was successful.

The frequency of endometrial adenomata in laparotomy scars, with relation to the operations by which they were preceded, is shown in Table 1.

Schwarz and Paddock (31) found endometrial adenomata in the abdominal scars of guinea pigs which had been subjected to cæsarean section.

The cases of endometrial adenomata occurring in laparotomy scars after the opening of the

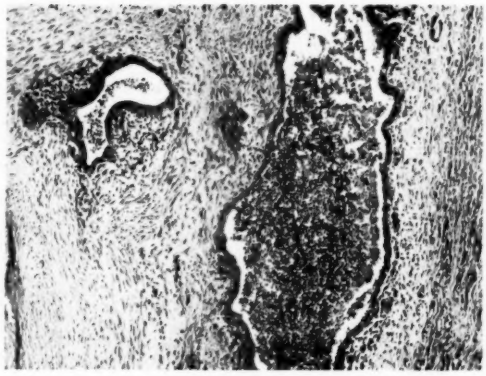

Fig. 1. Photomicrograph, Case 13, showing endometrial adenoma.

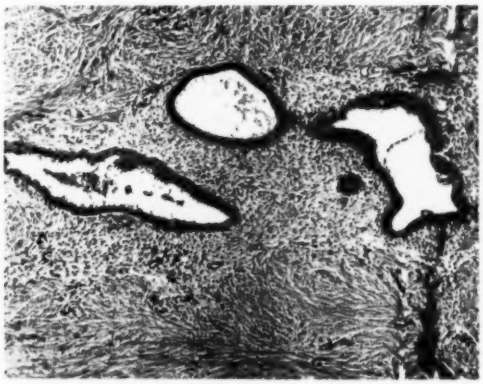

Fig. 2. Photomicrograph, Case 14, showing endometrial adenoma.

pregnant uterus have been collected and 2 new cases are added.

CASE 1. Von Franque (34) reported the case of a woman who had had an operation 4 years previous for rupture of the uterus during abortion. When examined, she had a tumor the size of a walnut in the abdominal scar, but no symptoms referable to it. The tumor was removed and was found to contain typical endometrium.

CASE 2. T. S. Cullen (10) reported the case of a woman, 34 years old, who had a repair of the uterus, ruptured during abortion 9½ years previous. There was a tumor nodule in the abdominal scar 1.5 by 2.5 by 3 centimeters. This was removed and proved to be an adenomyoma of the rectus muscle.

CASES 3 and 4. J. A. Sampson (27) reported these cases for F. B. Mallory of Boston. No clinical data was given but the two specimens were adenomata of the endometrial type found in the abdominal scar after cæsarean section.

CASES 5 and 6. C. F. Burnam reported these cases for T. S. Cullen in the discussion of J. A. Sampson's paper (11). A case of J. L. Stavey of Washington and one of E. A. Codman of Boston with adenomyomata in the abdominal scar following cæsarean section.

CASE 7. J. A. Sampson (28) reported a case of Good and Mallory. A woman, 30 years old, had a cæsarean section in 1913, a left salpingectomy in 1915, and a supravaginal hysterectomy in 1917. She noticed a small nodule in the abdominal scar a few weeks after the last operation. It gradually increased in size but was symptomless and was removed in 1922. It contained typical endometrial tissue.

CASE 8. N. S. Heaney (14) reported the case of a woman, 32 years of age, who had a cæsarean section in 1921. One year later a "sore lump" appeared in the abdominal scar and was tender and extremely painful during menstruation. Two years later a nodule the size of a walnut was removed from the rectus fascia. It was hard and contained many blood filled spaces. Microscopically it proved to be a typical endometrial adenoma.

CASE 9. N. S. Heaney (14) reported the case of a woman, 38 years old, who had a fundal incision and a 6 or 7 week ovum removed, with a round ligament operation and excision of the uterine ends of the tubes. She soon noticed a tender swelling in the scar, which became extremely painful and enlarged during menstruation. Three years later a nodule the size of a walnut was removed from the rectus fascia, on the first day of the menstrual period. It was found to contain many small hæmorrhagic cysts and microscopic examination revealed it to be an adenoma with typical endometrial glands in active menstruation.

CASE 10. W. C. Danforth (12) reported the case of a woman, 20 years old, who had a cæsarean section and excision of the uterine ends of the tubes for sterilization. She returned 2 years later with a tender, hard mass in the scar, which did not vary with the menstrual periods. It was excised and proved to be an endometrial adenoma.

CASE 11. O. H. Schwarz (30) reported a case for A. Trumper. A woman, 28 years old, had a cæsarean section with an uneventful convalescence 3 years previous. Two years after the operation she complained of a sensitive spot at the upper end of the abdominal scar, where a nodule the size of a cherry was found. The nodule was removed and microscopic study revealed the presence of endometrial tissue.

CASE 12. C. Berkeley (1) reported the case of a woman, 30 years of age, who had a cæsarean section in 1920. Three years later a small lump appeared at the lower end of the abdominal scar. The tumor gradually increased in size and was especially painful during the menstrual periods. When the patient was examined in 1925 the tumor was 1 inch in diameter, freely movable on the deep fascia, and tender, while the skin over it was adherent and pigmented. On removal the tumor was found to have no connection with the uterus or peritoneum. Microscopically it proved to be an endometrial adenoma.

The 2 following cases are from the Surgical Service of the Peter Bent Brigham Hospital, Boston.[1]

CASE 13. A woman, 28 years of age, gave a history of having been subjected to a cæsarean section 4½ years

TABLE I

Operation	Cases	Percentage
Ventrofixation of uterus	18	37
Opening of the pregnant uterus	12	25
"Pelvic operations" (salpingectomy, oophorectomy)	10	20
Suspension of the uterus	5	10
Appendectomy	3	6
Hysterectomy	1	2

[1] Maes (18) mentions 2 unreported cases seen in New Orleans, following Cæsarean section.

previously. Fifteen months before admission to the hospital she noticed two swellings in the laparotomy scar: one in the scar itself above the umbilicus and the other below and to the left as if it had appeared in a stitch-hole. Both swellings grew very slowly, the larger being only 1 centimeter in diameter at the time of examination. They became very tense and painful with each menstrual period and at that time one of them would occasionally burst, discharging blood upon the surface and considerable relief would be felt. After the period was over, there was an area of ecchymosis in the surrounding skin which gradually faded. The area surrounding the scar became very deeply pigmented. The whole affair seemed very mysterious to the patient and frightened her considerably. At operation by Dr. John Homans, the nodules, containing many blood filled cysts, were removed from the abdominal wall, where they were found to be attached to the uterus. Microscopic study showed an endometrial adenoma (Fig. 1).

CASE 14. A woman, 36 years old, had had a cæsarean section 8 years before admission to the hospital. Five years later she noticed a small nodule in the abdominal scar, which became slightly swollen and painful during the menstrual periods, but never discharged any bloody fluid. The skin about the scar was slightly pigmented but the nodule was not adherent to the skin. A nodule the size of a walnut, having no connection with the uterus, was removed from the rectus fascia by C. E. Bird. The peritoneum appeared normal. Microscopic study revealed an endometrial adenoma (Fig. 2).

SUMMARY AND CONCLUSION

Endometrial adenomata in the abdominal scar, following opening of the pregnant uterus, have been reported in 12 cases. These cases are here reviewed and 2 new cases are added.

The most frequent symptom is pain in the scar during the menstrual periods. Local excision is sufficient for removal of the tumor.

The implantation theory would seem to give the best explanation of the origin of this group of endometrial adenomata.

The occurrence following cæsarean section would suggest the use of the low type of uterine incision as the lining is chiefly cervical mucosa in that region.

BIBLIOGRAPHY

1. BERKELEY, C. J. Obst. & Gynec. Brit. Emp., 1926, xxxiii, 657.
2. BLUMER, G. Am. J. Obst., 1898, 37.
3. BONNEY, V. J. Obst. & Gynec. Brit. Emp., 1926, xxxiii, 658.
4. CASLER, D. B. Tr. Am. Gynec. Soc., 1919, xliv, 69.
5. CULLEN, T. S. Johns Hopkins Hosp. Bull., 1896, vii, 112.
6. Idem. Johns Hopkins Hosp. Rep., 1897, vi, 133.
7. Idem. Adenomyoma of the Uterus. Philadelphia: W. B. Saunders Co., 1908.
8. Idem. J. Am. M. Ass., 1914, lxii, 835.
9. Idem. The Umbilicus and Its Diseases. Philadelphia: W. B. Saunders Co., 1916.
10. Idem. Arch. Surg., 1920, i, 215.
11. Idem. Am. J. Obst. & Gynec., 1922, iv, 562.
12. DANFORTH, W. C. Am. J. Obst. & Gynec., 1925, x, 630.
13. GREEN, C. D. Tr. Path. Soc. Lond., 1899, i, 243.
14. HEANEY, N. S. Am. J. Obst. & Gynec., 1925, x, 625.
15. HENRY, J. S. Surg., Gynec. & Obst., 1927, xl, 637.
16. LEMON, W. S., and MAHLE, A. E. Arch. Surg., 1925, x, 150.
17. LOCKYER, C. Fibroids and Allied Tumors. London: The Macmillan Co., 1918.
18. MAES, U. Am. J. Surg., 1927, ii, 541.
19. MARTIN, A. Ztschr. f. Geburtsh. u. Gynaek., 1891, xxii, 44.
20. MEYER, R. Ztschr. f. Geburtsh. u. Gynaek., 1903, xliv, 32.
21. NICHOLSON, G. W. J. Obst. & Gynæc. Brit. Emp., 1926, xxxiii, 620.
22. NORRIS, C. C. Am. J. Obst. & Gynec., 1921, i, 831.
23. PFANNENSTIEL, J. Verhandl. d. deutsch. Gesellsch. f. Gynaek., 1897.
24. PRATT, J. P. J. Michigan M. Soc., 1927, xxvi, 82.
25. RUSSELL, W. W. Johns Hopkins Hosp., Bull., 1899, x, 8.
26. SAMPSON, J. A. Tr. Am. Gynec. Soc., 1921, xlvi, 162.
27. Idem. Am. J. Obst. & Gynec., 1922, iv, 451.
28. Idem. Surg., Gynec. & Obst., 1924, xxxviii, 287.
29. Idem. Arch. Surg., 1927, v, 217.
30. SCHWARZ, O. H. Am. J. Obst. & Gynec., 1927, xiii, 331.
31. SCHWARZ, O. H., and PADDOCK, R. Am. J. Obst. & Gynec., 1925, x, 153.
32. SEELIG, M. G. Am. J. Obst., & Gynec. 1926, xi, 461.
33. SEMMELINK, H. B., and DE JOSSELIN DE JONG, R. Monatschr. f. Geburtsh. u. Gynaek., 1905, xxii, 240.
34. VON FRANQUE, O. U. Zentralbl. f. Gynaek., 1916, xl, 953.
35. VON RECKLINGHAUSEN, F. D. Deutsch. med. Wchnschr., 1893, 825.
36. Idem. F. D. Die Aden. u. Cystaden. d. Uterus u. Tub. Berlin, 1896.
37. WEBER, F. Monatschr. f. Geburtsh. u. Gynaek., 1899, ix, 596.
38. WELLER, C. V. Am. J. Path., 1927, iii, 553.

CONTROLLABLE SPINAL ANÆSTHESIA IN OBSTETRICS

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AMERICAN medical literature does not contain a description of any technique whereby anæsthetic agents may be introduced into the subarachnoid space of the lumbar spine so as to produce caudal anæsthesia. Furthermore, a careful search of the literature fails to reveal that gliadin has ever been used to prevent dissemination of anæsthetic agents in spinal fluid, thereby controlling the extent of anæsthesia on the body surface.

In our experiments with controllable spinal anæsthesia, it has been definitely demonstrated that if 2 cubic centimeters of anæsthetic solution are injected into the subarachnoid space, anæsthesia will extend upward in the canal to and including the third and fourth lumbar nerves. In small spines it may extend as high as the second lumbar interspace, but if the amount of solution is decreased without a change in the amount of novocain it becomes possible to confine the anæsthetic to the lower portion of the spinal canal so that only the sacral nerves become anæsthetized (19), producing anæsthesia limited to the perineum, a typical saddle anæsthesia which is limited in front by the symphysis and in back extends over the lower part of the sacrum and down the inner side of the thighs for 5 or 6 inches. There is no impairment of motion or anæsthesia of the legs. The technique of limited spinal anæsthesia has been employed in 273 gynecological and rectal cases without any deviation, a typical caudal anæsthesia produced intradurally. The method of confining spinal anæsthesia to the legs and controlling its height on the body surface has been described in detail (18). Therefore, it would seem that the number of successful cases has been sufficient to justify mention of this particular form of technique.

In female patients, the cervix, vagina, perineum, vulva, and sphincters of the anus and bladder are completely anæsthetized, while sensation of the uterus is not impaired. The cervix can be dilated without pain, but curettement of the fundus is painful.

Realizing the possibility of these results in obstetrics, we prevailed upon the Obstetrical Department to permit the use of this form of limited spinal anæsthesia in their difficult cases. The results were so satisfactory in 89 cases of instrumental deliveries, versions, breech cases, and prolonged labors that it seems worth while to report the findings and the deductions which have been made.

After the first two deliveries with the patient in a Trendelenburg position, the impracticability of a solution of light specific gravity was apparent and glucose was substituted for the alcohol in the controllable spinal anæsthetic preparation (18), and a 40 per cent instead of a 10 per cent novocain solution employed. This permitted the same limited anæsthesia and allowed the patient to repose comfortably in a semi-reclining position throughout delivery.

The technique of controlling the anæsthetic solution and limiting its contact to those strands of the cauda equina that pierce the tip of the dural sac, forming the sacral nerves (Fig. 14), is relatively simple with the use of gliadin (the mucilaginous content of wheat starch) which prevents dissemination or mixing of the anæsthetic solution with the spinal fluid until the anæsthetic agent has been absorbed. Too much gliadin in the solution eliminates all anæsthetic properties or greatly delays anæsthesia. Too little gliadin causes the solution to be devoid of all controllable features. The gliadin also has much to do with the lessening of the toxic symptoms of the novocain. With this preparation, 200 or even 400 milligrams (21) of novocain may be employed and will give less reaction than when 100 milligrams are dissolved in the spinal fluid and reinjected.

The technique employed in the use of this solution varies somewhat from other forms of spinal anæsthesia. When deviations from the ordinary routine of other methods of spinal anæsthesia are employed, an explanation will be made.

When local conduction or spinal anæsthesia is used, the paramount issue at all times is never to hurt the patient in any way at any time. A patient once hurt may lose confidence in the method and in the doctor. A confidence once lost may be very hard to regain and many times constitutes the direct cause of unsuccessful anæsthesias. A patient that is immediately subjected to one painful manipulation becomes over apprehensive of every following procedure. In spinal anæsthesia with novocain it must be remembered that tactile sensation is not abolished.

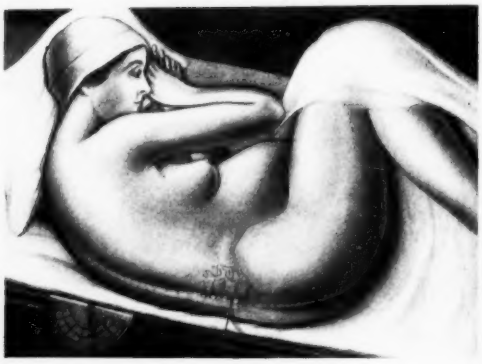

Fig. 1. The head of the table is elevated 18 degrees as measured by the tiltometer. The patient's knees are flexed, the head is bent forward, and the back is bowed out. The correct position.

Fig. 2. Sitting posture. The elbows rest on the knees, the head is bent forward, and the back is bowed out.

All the more reason why every precaution should be taken and the technique employed with such finesse, that spinal anæsthesia may be administered without producing any pain. With an entirely satisfactory anæsthesia, the patient should be at ease, comfortable, and cheerful throughout delivery.

To perform the lumbar puncture, raise the head of the delivery table from 15 to 20 degrees (Fig. 1). This degree of elevation is hard to judge but is readily measured by the use of the tiltometer. The patient is then in a slightly reverse Trendelenburg position and should be kept so throughout the course of delivery. If for any reason this is impossible she may be placed nearly flat, but not until after the anæsthesia has become fixed, namely from 12 to 15 minutes. If an adjustable delivery table is not available, pillows may be employed to secure a similar position (Fig. 12).

Fig. 3. Raising the cutaneous wheal at the point of puncture with 0.5 cubic centimeters of ephedrine-novocain solution.

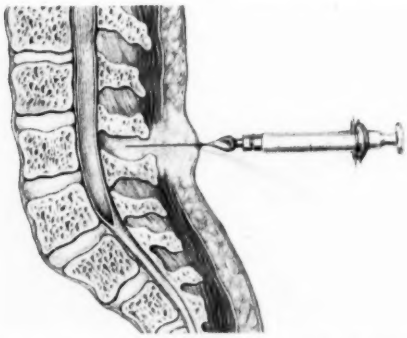

Fig. 4. Showing the anæsthetization of the interspinous ligament and subcutaneous tissues at the point of puncture.

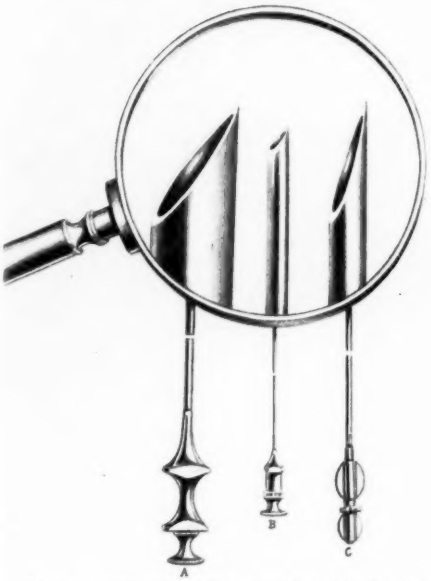

Fig. 5. Compare the size of needle *A* with *B*. Also compare the taper of needle *C* with that of needle *B*, the author's spinal puncture needle.

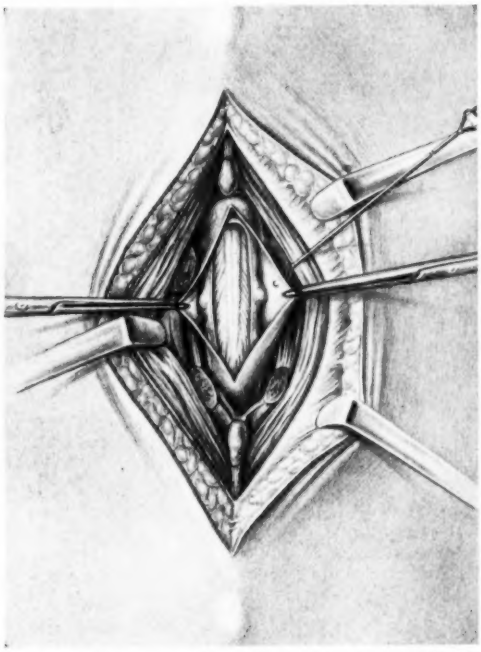

Fig. 6. Illustrating the miniature trap-door cut in the dura made with the author's needle.

The patient should be turned on her side, preferably the right. The knees should be flexed upon the abdomen, the head bent forward, so that the chin rests on the chest, and the back bowed out (Fig. 1). The shoulders and hips should be in a vertical line. If the shoulders are tilted and the hips remain vertical or if the hips are tilted and the shoulders perpendicular, a cork-screw spine will be produced and may present difficulty at the time of puncture. A scaphoid back should be avoided as this causes the spinous processes of the vertebræ to over-ride and makes puncture difficult and painful. If the physician is unfamiliar with the technique of this position the patient may be permitted to sit on the edge of the delivery table with the feet hanging over the side, the body bent forward, the elbows resting on the knees, and the back bowed outward (Fig. 2). She may be permitted to remain in this position for from 10 to 12 minutes until anæsthesia becomes fixed or may immediately be placed in a semi-reclining position with the head of the table elevated as already described. However in the sitting position the patient's comfort and ease is disturbed. Never permit the patient to lie

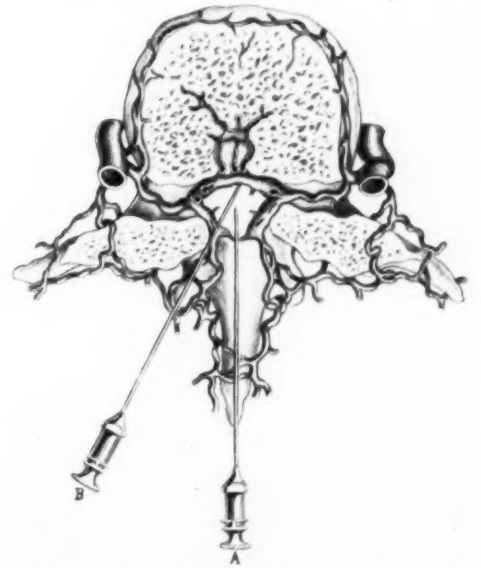

Fig. 7. *A*, The correct way to make a spinal puncture. *B*, the incorrect way. Note the extensive venous supply.

Fig. 8. The shaded portion represents the anæsthetized field as seen from the front. Note the sharp line of demarcation over the symphysis.

Fig. 9. The extent of anæsthesia as seen from the back.

entirely flat or in a Trendelenburg position (22) when the heavy solution is used, as there is danger that the solution may ascend high in the canal and produce a drop in blood pressure, nausea, vomiting, and headaches.

The skin from the eighth dorsal to the lower part of the sacrum is painted over an area 5 or 6 inches wide with a 3 per cent tincture of iodine. If for any reason iodine is contra-indicated 5 per cent mercurochrome may be substituted. The logical site to introduce the spinal puncture needle for this particular form of anæsthesia would be the lumbosacral interspace so as to introduce the anæsthetic solution directly at the site of contact, but unfortunately in a number of cases we have found that the dural sac terminates above this interspace, therefore the fourth interspace is selected as the site of puncture. This may easily be determined by palpating the spinous processes along an imaginary line drawn between the crests of the ilia. When the interspace between the fourth and fifth lumbar vertebræ has been determined, it may be marked by firm pressure with the thumb nail of the gloved hand. At this site a cutaneous wheal is raised with 0.65 cubic centimeter solution of novocain, 0.013; ephedrine, 0.5; and normal saline, qs., 1.3.

A fine 25 or 27 gauge hypodermic needle is used (Fig. 3). The needle is not withdrawn but is carried directly into the interspinous ligament (7) and the other 0.65 cubic centimeter of the solution injected as the needle advances. One should endeavor to inject the solution a little faster than the needle proceeds, so that the needle is introduced into a freshly anæsthetized area (Fig. 4). To avoid the unpleasantness of having to dig out a broken needle it is advisable to have the needle equipped with a safety guard similar to the one shown in the drawings.

Spinal puncture is made through the center of the wheal raised with the novocain-ephedrine solution with a fine 22 gauge lumbar puncture needle. The needle should have a short bevel of 45 degrees (Fig. 5, *B*) as in the author's spinal puncture needle. The rear part of the bevel is rounded in such a manner that it has no cutting surface, while the reverse side of the point is ground so as to produce a spear point. When this needle pierces the dura it cuts a miniature trap door (18) which is closed by the intradural pressure when the needle is withdrawn (Fig. 6). The spear point of the tip permits easy penetration of the skin and tissues. For many reasons, rustless steel needles are superior to nickeloid or nickel-plated ones. The point remains sharp longer than that of the ordinary needle. There is no nickel plating to peal off. The needle will not tarnish, become rough, or pit; it will not rust on the inside nor break unexpectedly; and it is tempered so that it will stand extreme bending and manipulation without breaking. In every case, the stylet should be removed and the needle bent into a semi-circle before it is sterilized. This testing may prevent the unpleasantness of removing a broken needle from the interspinal ligament.

Avoid using a needle of large caliber, such as the old Bier 15 to 17 gauge needle (Fig. 5, *A*),

Fig. 10. The nerves to the *1*, fundus of the uterus; *2*, ovary; *3*, bladder, *4*, tube; *5*, branches of the hypogastric plexus; and *6*, the sympathetic are not anæsthetized. The following are anæsthetized: *I*, the pudendal plexus; *II*, and the cervical, vaginal, and vesical nerves; *III*, perineal; *IV*, cutaneous; *V*, posterior nerve of the clitoris; *VI*, labial; *VII*, middle hæmorrhoidal; *VIII* inferior hæmorrhoidal and sphincter ani from the sacral plexus. The fourth and fifth lumbar (*L IV* and *L V*) and the first sacral (*S I*) are sometimes anæsthetized.

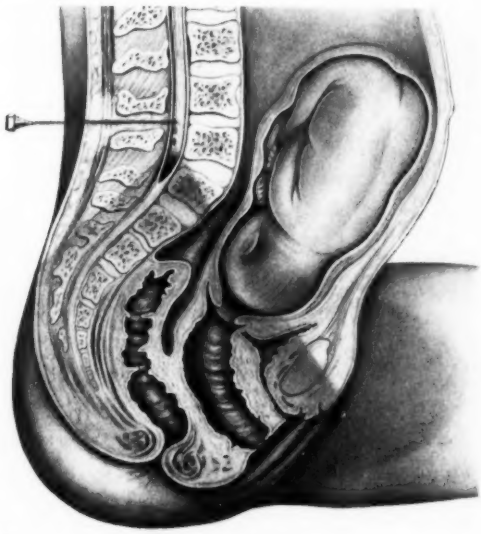

Fig. 11. When the anæsthetic solution is introduced into the subarachnoid space it gravitates to the extreme tip of the dura and produces anæsthesia of the tissues as shown by the shaded area.

which will not only cause unnecessary pain when it is introduced, but will traumatize the tissues and often produce postanæsthetic backache. A large needle may produce intradural hæmorrhage or it may injure or cut the cauda and permit seepage of spinal fluid into the extradural tissues, because of the large hole left in the dura. Long, tapered (Fig. 5, *C*) needles produce bleeding more frequently at the time of puncture. With their use anæsthesia is frequently unsatisfactory, because a part of the taper is within the dura and the remainder outside, or a part of the taper is within a vein and the remainder in the dural sac. Should only a part of the taper be within the dura, some of the solution is deposited extradurally. Anæsthesia will be unsatisfactory or incomplete. Should part of the taper be within a vein when the solution is injected, convulsions may ensue. With a short tapered needle as shown, these undesirable complications rarely occur. When the puncture is made through the interspinous ligament, care should be taken not to deviate to the right or left. The puncture should be at right angles to the long axis of the spine. Never attempt a puncture between the laminæ (Fig. 7, *B*). Avoid inserting the needle in an upward direction or at an acute angle to the spine. The veins about the cord are large and numerous but may be avoided and not penetrated if the spinal puncture is made in the manner described. (Figs. 7, *A*, and 11). Unnecessary bleeding will surely be produced should the puncture be attempted between the laminæ with the needle tilted, with a needle of large caliber, or with a long tapered point.

When the dura is punctured there is a slight snap, which is recognized after the first few punctures, and the needle advances with less resistance. If possible, avoid piercing the opposite side of the dura with the point of the needle, or coming in contact with the body of the vertebra, because this also will cause bleeding (Fig. 7, *B*). With the assurance that the dura has been entered, the stylet is removed and spinal fluid should flow through the needle. If no spinal fluid appears, rotate the needle on its own axis. If there is still no spinal fluid, insert the needle deeper. If bony resistance is felt (the body of the

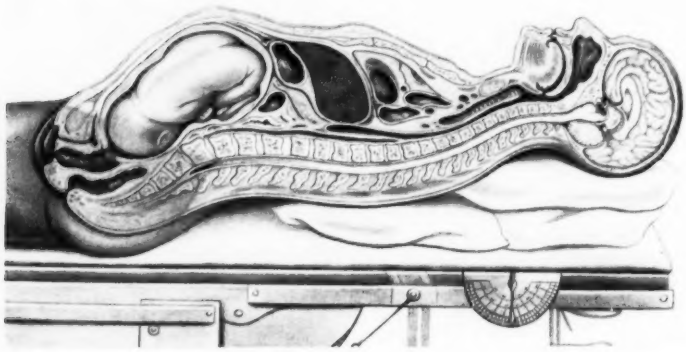

Fig. 12. The method of employing pillows in order to secure the semi-reclining position when an adjustable maternity table is not available.

vertebra), the needle has undoubtedly deviated to one side. It should be withdrawn to the skin surface and re-inserted at a slightly different angle to the right or left as the case may be. Always have the stylet in place when making manipulations. Occasionally the first drop or two of spinal fluid will contain blood. If this clears the injection may be made. If not, the needle should be withdrawn and re-introduced. The injection of the anæsthetic solution should never be made until clear spinal fluid flows through the needle, which is the only assurance that the point of the needle is within the dural sac. Unless the solution is injected into the subarachnoid space, anæsthesia will not be satisfactory.

It is advisable to fill both hypodermic syringes with the respective solutions before spinal puncture is started. The filled syringes and needles should be placed in a convenient position to the operator before the procedure is started. Attach the syringe with the solution containing: novocain, .2; gliadin solution, .13; strychnine sulphate, .0022; glucose, .065; and normal saline, qs., .5 to the spinal puncture needle. Aspirate one or two drops of spinal fluid to make sure that the needle has not been displaced, then slowly inject the contents of the syringe. Do not again aspirate or in any way attempt to mix the solution with

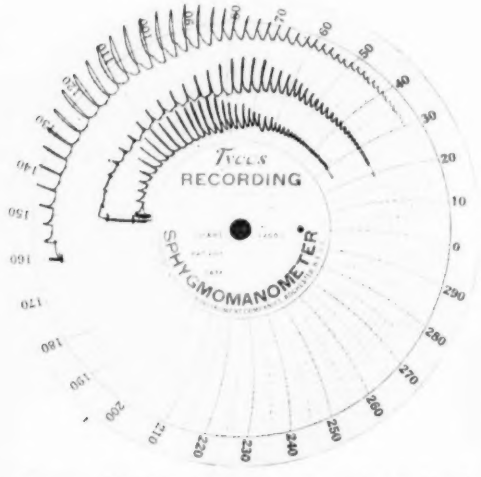

Fig. 13. A blood pressure tracing. Lower line, before the anæsthetic was injected; center line, 20 minutes later; top line, 2 hours after injection. Note the increased volume of the heart beats in the upper line.

Fig. 14. Showing the limited field of contact of the anæsthetic intradurally. Sodium iodide was used in order to cast a shadow. The specific gravity of the solution was not altered.

the spinal fluid. Withdraw the needle and cover the puncture wound with collodion or a small square of adhesive plaster. Turn the patient on her back. Anæsthesia will be complete as soon as the patient can be prepared and draped. This procedure limits the contact of the solution to the lower tip of the dural sac and causes anæsthesia of the perineum only (Fig. 8).

It is better to have a syringe with a secure locking device to insure a tight fit to the needle (Fig. 3), thus preventing the possibility of injecting air into the dural sac or leakage at the connection. With a locking device on the syringe, the needle may be manipulated, if necessary, and if the patient moves there is little chance that the syringe will be disconnected from the needle, and some of the anæsthetic solution lost. With the locking device employed, needles never become "jammed" and there is no leaking at the connection.

The semi-reclining or reverse Trendelenburg position of from 15 to 20 degrees should be maintained for 1½ to 2 hours after injection so as to avoid the possibility of having the anæsthetic ascend in the canal; also by retaining the anæsthetic low in the dural sac, headaches will be greatly diminished. If for any reason anæsthesia is desired higher on the body surface it can be obtained by mixing the solution with spinal fluid. This is done by aspirating and re-injecting 2, 4, or 6 cubic centimeters of the spinal fluid. Four cubic centimeters, aspirated and re-injected, will produce anæsthesia of the legs. Six cubic centimeters will carry anæsthesia to the umbilicus and 8 cubic centimeters to the costal margin. For the higher anæsthesia the viscid alcohol solution is preferable as this will permit the patient to be placed in a level or Trendelenburg position. The heavy solution should never be used when the head is to be lowered.

Pre-operative narcotics are not necessary in this form of anæsthesia. The relief of pain afforded the mother allays all fear and apprehension. Morphine and scopolamine, if used, may possibly so affect the child that strenuous resuscitation methods will be necessary. The mother may remain in a dorsal recumbent position or may be placed in stirrups without effecting the limitation of the anæsthesia provided the body is kept in a reverse Trendelenburg of from 15 to 20 degrees.

Many advantages of controllable spinal anæsthesia were found in a study of 3,724 cases of general surgery including 68 cæsarean sections and 89 obstetrical cases, as compared with various forms of inhalation anæsthesia. The apparatus required for the introduction of this anæsthesia is comparatively inexpensive and may be found in almost every physician's outfit: two (2) cubic centimeter hypodermic syringes, one hypodermic needle, one spinal puncture needle, and the anæsthetic solution.

The technique is very simple. No greater knowledge is required than that of doing an ordinary diagnostic lumbar puncture, the details of which are familiar to every physician. Should there be any doubt as to the simplicity of the procedure, 10 minutes' practice on the cadaver will familiarize any physician with the ease with which a lumbar puncture may be made in the fourth interspace.

A limited spinal anæsthesia may be administered by the operator himself, thereby eliminating the necessity of an anæsthetist or an assistant. This would appear to be a very great advantage in emergencies, in isolated or country practice, or in small hospitals without internes.

The anæsthesia is quickly secured in from 1 to 3 minutes after injection. It becomes fixed within from 10 to 12 minutes. Satisfactory and complete anæsthesia occurs in over 99 per cent of cases. On account of the ease of introduction and rapidity of action, it is better than sacral or caudal anæsthesia, (17) which is invariably delayed from 15 to 25 minutes after injection. Caudal anæsthesia is estimated to be unsatisfactory or incomplete in from 15 to 25 per cent of cases. The injection of the hiatus requires considerable skill and practice, the same may be said of parasacral anæsthesia, to say nothing of the pain frequently caused as a result of inexperience or awkwardness.

The safety of an intradural sacral anæsthesia is much greater than ordinary spinal anæsthesia and may be conservatively estimated as being as safe as caudal anæsthesia. The mother suffers no shock or drop in blood pressure (Fig. 13). There is no danger of suffocation, cyanosis, strangulations, or swallowing of the tongue or false teeth as with inhalation anæsthesia. The child is better protected than with any other form of anæsthesia. Asphyxiation or cyanosis of the child is rare. The effects of morphine, scopolamine, ether, chloroform, various other narcotics, and anæsthetics are unquestionably transmitted to the child, and at times make resuscitation difficult. A distinct advantage is that the anæsthesia may be confined to the perineum or carried to any desired height on the body surface by expanding the solution as described in the technique. It also eliminates postanæsthetic complications. Due to its limited field of contact intradurally (Fig. 11) it does not produce the after-effects encountered with stovaine or neocaine spinal

TABLE I.—CONTROLLABLE SPINAL ANÆSTHESIA

Age	Diagnosis	Point of Injection	Amt. of Novocain, Mgm.	Amt. of Ephedrine, Mgm.	Operation	Blood Pressure Before Operation	Blood Pressure During Operation	Blood Pressure At Completion	Time of Anæsthesia (Minutes)	Duration of Anæsthesia	Upward Extent	Pallor	Nausea	Vomiting	Remarks and Postoperative Reaction
DR. DAVIS BAKER, GLENS FALLS HOSPITAL, GLENS FALLS, NEW YORK															
44	Carcinoma of cervix uteri	2nd lumbar	200	50	Insertion of radium	120–65	115–65	115–70	5	1 hr. 40 min.	Costal margin	No	No	No	Slight vomiting postoperative
28	Ruptured extra-uterine pregnancy	2nd lumbar	200	50	Salpingectomy	105–58	100–65	100–65	4	1 hr. 30 min.	Umbilicus	No	No	No	Perfect anæsthesia. No reaction.
35	Contracted pelvis, pregnancy	3rd lumbar	200	50	Cæsarean section	160–90	150–90	150–85	5	1 hr. 50 min.	Mid-epigastrium	No	No	No	Perfect anæsthesia. No reaction.
71	Strangulated hernia	3rd lumbar	200	50	Herniotomy	175–85	170–90	170–90	6	1 hr. 40 min.	Umbilicus	No	No	No	No reaction.
45	Retained secundines	4th lumbar	200	50	Dilatation and curettage	128–65	120–60	125–60	6	1 hr. 40 min.+	Symphysis	No	No	No	Perfect anæsthesia. Slight headache following day.
DR. LINCOLN F. SISE, LAHEY CLINIC, BOSTON															
24	Chronic pelvic inflammation	4th lumbar	200	50	Hysterectomy	120–60	115–60	115–60	5	1 hr. 50 min.	Costal margin	No	No	No	No reaction.
42	Hernia	4th lumbar	200	50	Herniotomy	130–90	135–90	135–90	7	1 hr. +	Anterior superior spine	No	No	No	No reaction.
43	Gall bladder and hernia	1st lumbar	260	50	Cholecystectomy Herniotomy	140–60	130–65	140–65	7	1 hr. 90 min.	Nipple	No	No	No	Postoperative reaction good
34	Tuberculous kidney	1st lumbar	250	50	Nephrectomy	140–90	126–82	140–85	6	1 hr.+	Mid-epigastrium	No	No	No	Postoperative reaction good.
27	Chronic salpingitis	3rd lumbar	200	50	Salpingectomy Appendectomy	130–70	135–70	135–70	4	1 hr. 35 min.+	Mid-epigastrium	No	No	No	Postoperative reaction good.
DR. A. I. WILLINSKY, TORONTO, CANADA															
48	Obstructive jaundice	3rd lumbar	200	100	3 stones removed from common duct	160–90	170–80	180–80	7	1½ hrs.	Nipples	No	Slight	No	Good. Had a cholecystectomy 3 yrs. previous. Preferred spinal to ether.
45	Prolapse of uterus	4th lumbar	200	100	Vaginal hysterectomy	128–70	160–80	140–90	3	1½ hrs.	Symphysis	No	No	No	Very easy to do because of reaction of tissues.
84	Prostatic obstruction	4th lumbar	200	50	Prostatectomy	130–90	150–90	120–90	5	1 hr.	Umbilicus	No	No	No	No discomfort
42	Uterine fibroids	3rd lumbar	200	100	Pan-hysterectomy	138–90	180–90	160–88	7	1½ hrs.	Costal margin	No	No	No	Good.
71	Prostatic carcinoma	4th lumbar	200	100	Perineal prostatectomy and radium	140–90	170–90	150–90	4	1 hr.+	Umbilicus	No	No	No	Good; no untoward after-effects.
DR. FRANK A. KELLY, GRACE HOSPITAL and RECEIVING HOSPITAL, DETROIT, MICHIGAN															
33	Ruptured ectopic	4th lumbar	200	50	Salpingotomy and appendectomy	160–70	150–60	150–50	10	120 min.	Mid-epigastrium	No	Slight	No	Excellent. No gas distention. Voluntary bowel movement. No urinary retention.
65	Caruncle of urethra	4th lumbar	150	50	Fulguration	164–78	192–88	192–90	21	1¾ hr.	Symphysis	No	No	No	A definite delay in anæsthesia.
56	Ovarian cyst	4th lumbar	200	50	Oophorectomy, appendectomy	165–30	165–30	165–30	8	1 hr. 30 min.+	Mid-epigastrium	No	Yes	twice	No postoperative vomiting, distention, or retention.
57	Exploratory. Cancer of rectum	3rd lumbar	200	100	Colostomy	102–64	118–74	112–72	5	1 hr. 30 min.+	Umbilicus	No	No	No	Uneventful.

					Trachelorrhaphy	130–70	116–70	110–68	5	1 hr. 30 min.	Mid-epigastri-	No	Yes	once	No distention or retention.

57	Exploratory. Cancer of rectum	3rd lumbar	200	100	Colostomy	102–64	118–74	112–72	5	1 hr. 30 min.+	Umbilicus	No	No	No	Uneventful.

24	Lacerated cervix, retroversion, salpingitis	3rd lumbar	200	50	Trachelorrhaphy salpingectomy	120–70	116–70	110–68	5	1 hr. 30 min.	Mid-epigastrium	No.	Yes	once	No distention or retention. Normal bowel movement following day.

DR. B. PRICHARD AND DR. FREDERICK S. WEATHERALL, DEPT. OF GYNECOLOGY, SYRACUSE UNIVERSITY, MEMORIAL and ST. JOSEPH'S HOSPITALS, SYRACUSE, NEW YORK

29	Chronic endocervicitis	4th lumbar	150	50	Sturmdorf of cervix	120–80	120–85	120–80	4	1½ hr.	Umbilicus	No	No	No	Satisfactory convalescence.
21	Abscess of Bartholin's gland	4th lumbar	150	50	Incision	120–80	128–70	120–80	4	2 hr.	Symphysis	No	No	No	Complete relaxation of vaginal orifice.
45	Strangulated hernia	4th lumbar	200	50	Herniotomy	140–90	128–78	140–100	6	1 hr. 45 min.	Umbilicus	No	No	No	No postoperative distention.
23	Pregnancy, active tuberculosis	4th lumbar	200	50	Therapeutic abortion	120–80	140–96	120–85	4	2 hr.	Umbilicus	No	No	No	No marked bleeding, no bad after-effects. Active tuberculosis.
27	Incomplete abortion.	4th lumbar	200	50	Dilatation and curettage	120–80	130–80	120–85	5	1¾ hr.	Symphysis	No	No	No	The relaxation of the cervix in this type of case is especially noticeable. This is also true of the sphincters in hæmorrhoidectomies.

DR. SIMON D. EHRLICH, FLOWER HOSPITAL, ST. MARK'S HOSPITAL, AND BETH ISRAEL HOSPITAL, NEW YORK

24	Tuberculosis of left kidney	12th dorsal	200	50	Nephrectomy	120–80	140–80	136–80	5	1 hr. 40 min.	9th rib	No	No	No	Systolic murmur. Râles upper right lobe.
48	Hæmorrhoids	3rd lumbar	200	50	Hæmorrhoidectomy	108–60	108–60	126–70	3	1 hr.	Symphysis	No	No	No	Postoperative course good. Very nervous before operation. Reaction good.
28	Chronic appendix, endometritis, endocervicitis	2nd lumbar	200	50	Appendectomy, dilatation and curettage, and amputation of cervix	110–80	114–70	124–60	4	1 hr.+	Costal margin	No	No	No	Apprehensive. Postoperative course good.
42	Hæmorrhoids and fistula in ano.	2nd and 3rd lumbar	200	50	Hæmorrhoidectomy excision of fistulous tract	125–70	108–60	116–60	10	1½ hr.+	Umbilicus	No	No	No	Anæsthesia delayed, head of table raised for a short time. Anæsthesia good.
29	Ovarian cyst and chronic appendicitis	2nd lumbar	200	50	Resection of ovary and appendectomy	125–90	120–80	125–80	6	1 hr.+	Costal margin	No	No	No	General condition good. Color fine.

DR. MEREDITH F. CAMPBELL, UROLOGICAL SERVICE, BELLEVUE HOSPITAL, NEW YORK

21	Calculus in lower ureter	2nd lumbar	200	50	Ureterotomy	114–68	112–50	122–68	4	1 hr. 40 min.	9th rib	No	No	No	Uneventful recovery. Complete relaxation.
55	Stricture of urethra, urinary extravasation	4th lumbar	200	50	External and internal urethrotomy	140–90	135–80	155–80	3	1 hr. 40 min.	Symphysis	No	No	No	Solution not mixed. Extreme Trendelenburg. No reaction.
48	Renal calculus	2nd lumbar	200	50	Pyelotomy	110–80	120–68	120–70	5	1 hr.+	9th rib	No	No	No	Contraction of intestines afford roomy opening in which to work.
42	Stone in upper ureter	1st lumbar	200	100	Ureterotomy	102–64	122–78	116–78	5	1 hr.+	9th rib	No	No	No	1 stone in ureter.
78	Carcinoma of bladder	1st lumbar	200	50	Superpubic cystotomy, cauterization of bladder tumor and radium implantation.	220–85	216–96	212–108	5	1 hr. 30 min.	Umbilicus	No	No	No	50 mgm. of ephedrine during operation. Operative risk poor.

anæsthesia, such as vomiting and headache (13). It does not affect the heart as does chloroform and has no effect upon the kidneys or liver as has ether (2). Postoperative lung and intestinal complications are reduced to a minimum.

Dehydration is not produced with this form of anæsthesia (10). A distinct advantage in cases of eclampsia and toxæmia is that water or liquids may be given freely before, during, and after delivery.

It assures the co-operation of the patient throughout delivery, which is a great help when it becomes necessary to change the patient's position, particularly when assistants are unavailable. The patient is able to "bear-down" and aid in delivery.

It may be given to patients with bronchitis or influenza without harm. Cardiacs, nephritics, alcoholics, addicts, or patients suffering with primary or pernicious anæmia take this form of anæsthesia much better than inhalation. Hypertension or hypotension is not affected. Regulation of the amount of ephedrine controls the blood pressure.

Shock is eliminated (11). The reflexes are blocked. Severe and prolonged cases are carried through with little if any change of condition. There is no unpleasant postpartum reaction.

Vomiting during or after delivery is a rare occurrence. This may be accounted for by the fact that the blood pressure is not affected and the splanchnics are not anæsthetized.

Distention or ileus does not occur as with inhalation anæsthesia. The sphincters are relaxed. peristalsis is stimulated—a distinct advantage especially for the patient's comfort.

It increases the patient's comfort during and after delivery. There is no lowering of her resistance. Nourishment may be taken immediately after delivery (9).

The blood pressure is not affected. This is a distinct advantage over other forms of spinal anæsthesia, which cannot be administered in severe cases of hypotension. It has been used with success in cases in which the systolic pressure was 78 without change throughout the procedure.

Postpartum hæmorrhages are less frequent. The uterus contracts quickly and firmly after delivery. Pituitrin may be used without fear. The anæsthetized cervix offers little or no resistance to the advancing head.

The cervix and perineum are protected, to a greater extent, from trauma and lacerations. The amount of relaxation and elasticity of these parts when anæsthetized is amazing.

Cystoceles are not apt to be a postpartum complication. The bladder spontaneously empties during delivery because the sphincter is anæsthetized.

Vaginal cæsareans may be eliminated. The cervix readily dilates or may be dilated manually with ease.

The mortality and morbidity of obstetrical cases are reduced because shock to the mother and postpartum anæsthetic complications do not occur. The child is offered greater protection, because there is less trauma in forcible deliveries as a result of the relaxation of the soft parts and because there is no absorption of toxins from narcotics or inhalation anæsthetics.

The disadvantages of intradural sacral anæsthesia in obstetrics appear to be few and of little consequence. The so-called dry taps may be advanced as a disadvantage. It is doubtful if such a condition really exists and may be attributed more to inexperience than to any pathological condition. Possible injury to the cauda equina may be considered. When such a complication exists it is not infrequently traceable to a bungling technique or the use of large spinal puncture needles.

Perhaps one of the greatest disadvantages that can be attributed to this form of anæsthesia is its duration, which is from 90 to 120 minutes. Should the duration of the delivery exceed the time of the anæsthesia there is no reason why a second injection should not be given. The duration of a second injection of the anæsthesia is invariably longer than the first 2 to 3 hours.

It is hoped that our intentions will not be misinterpreted or misconstrued. We do not wish to imply that this is the ideal and only form of anæsthesia to be employed in obstetrics. It is offered as being simpler, quicker, and more efficient than caudal or sacral anæsthesia, and as a method of relieving pain, suffering, and misery in those unfortunate cases in which various forms of inhalation anæsthesia would be detrimental to mother or child or both.

The indications in obstetrics for limited spinal anæsthesia in preference to inhalation anæsthesia are so logical and well-founded that if the patient's welfare is to be considered, a working knowledge of this form of anæsthesia should be possessed by all obstetricians so that the dangers of inhalation anæsthesia in certain obstetrical cases may be avoided and many useful lives saved.

There appears to be no well grounded or sound reason why inhalation anæsthesia should be used in tuberculosis (6), acute, chronic, or arrested cases. In acute tuberculosis the condi-

tion is invariably made worse, to say nothing of the numerous pulmonary complications that may develop. Not infrequently the chronic or arrested case is converted into an active case. To administer any form of inhalation anæsthesia to a patient suffering with acute or chronic bronchitis is to run the risk of fatal pneumonia.

Patients suffering with asthma or emphysema appear to be greatly relieved with the administration of spinal anæsthesia. Perhaps this is due in part or almost wholly to the effect of the ephedrine. At any rate the after-effects of inhalation anæsthesia should always be borne in mind in this particular class of cases.

In cardiac conditions with decompensated hearts, the cyanosis produced by the efforts of labor pains is relieved at once. Dyspnœa is lessened and the patient's condition relieved instantly. If apnœa is present, the patient is able to assume a reclining position without discomfort. High spinal anæsthesia relieves these conditions entirely.

In cases of eclampsia (24) and toxæmias of pregnancy the kidneys are not affected as with ether. Suppression does not occur and elimination is not affected. The patient is not dehydrated. There is no primary withholding of fluids at the time of delivery or secondary loss by vomiting as a result of inhalation anæsthesia.

The acidosis (12) which is invariably present in this type of case is not increased but is often lessened because of the increased peristalsis and relaxation of the sphincters. Any form of inhalation anæsthesia, however, will increase acidosis and should never be given when acetone or diacetic acid is present in the urine.

The renal elimination in nephritics (1) without eclamptic symptoms is not affected with spinal or sacral anæsthesia. It might be said that chloroform could be used with safety, but we must not forget the cloudy swelling and fatty degeneration of the liver and kidneys and the effects thereof 4 or 5 days postpartum. Some will say that nitrous oxide or ethylene could be used without harm. Our experiments on animals invariably show that with these forms of anæsthesia, hæmorrhage in the glomeruli is produced.

If pyelitis or pyelonephritis occurs at the time of labor or if either has recently been present, the patient should not be subjected to the harmful possibilities of inhalation anæsthesia. In fully 50 per cent of the cases in which pyelitis or pyelonephritis is dormant or has subsided it will recur following general narcosis.

Severe cases of hypertension call for this form of anæsthesia and not infrequently do we see a permanent drop of from 10 to 20 points after its use. By carrying the anæsthetic higher in the canal, a greater drop can be obtained if desired.

Diabetes is a serious complication at best and one not easily dealt with. Spinal or sacral anæsthesia would appear to be the only safeguard in these cases.

In the anæmias of pregnancy, either primary or pernicious, better results are obtained with spinal anæsthesia. There is less hæmorrhage at the time of delivery, no vomiting or dehydration, and the blood chemistry is not changed.

The patient with a short fat neck takes inhalation anæsthesia badly, but does not seem to mind spinal anæsthesia. On patients suffering with goiter (25), exophthalmic or toxic adenoma, spinal or local anæsthesia has little effect, provided adrenalin is not used. They invariably take inhalation anæsthesia badly and cardiac complications may cause it to be absolutely contraindicated.

In cases of severe shock due to long tedious labor, in which delivery has been attempted at home without success and the patient has then been brought to the hospital, spinal anæsthesia may be successfully used. These patients greatly improve by the judicious and free use of ephedrine.

In prolonged and difficult labor (23) in which the physician has reason to believe that delivery will take place without instrumental interference, a rest period from pain may be produced with spinal anæsthesia and the patient permitted to regain some of her strength. Not infrequently the relaxation of the soft parts favors quick, easy delivery.

An example of this may be shown in a primapara, 32 hours in labor, with the cervix dilated 3 fingers. A limited spinal anæsthesia was given, the cervix became soft and completely dilated within 20 minutes, and offered little or no resistance to the oncoming head. The child was delivered 48 minutes after the subarachnoid injection and the mother was perfectly at ease. She suffered no pain, and smiled as the head advanced over the perineum.

The rigid or spasmodic cervix is little affected with inhalation anæsthesia. With spinal anæsthesia the cervix quickly becomes soft and flabby and offers little or no resistance to the oncoming parts or is easily dilated by manual efforts. The so-called Bandl's ring or hour-glass contraction is not relieved with a limited spinal anæsthesia. If such a condition exists, it will be necessary to carry the anæsthetic high enough in the spinal canal to anæsthetize the hypogastric plexus or

to the ninth dorsal vertebra. If this is done the spasm and contraction are relieved much more readily than with inhalation anæsthesia. Cases of cæsarean section, ruptured uteri, or ruptured ectopics call for this form of anæsthesia, not only for the greater protection it offers the mother and child, but because it eliminates to a great extent postoperative distention or ileus. The surgeon has better working conditions. There is less trauma to the abdominal wall, no handling of intestines, less bleeding, and a shorter convalescense.

Forceps are apparently applied with greater ease and extraction is accomplished with less effort. The amount of relaxation and elasticity in the anæsthetized perineum is almost incredible. If the cervix is not fully dilated, it may be manually dilated with little or no effort. The cooperation of the mother and normal uterine contractions assist materially in the delivery. There is less trauma to the child and lacerations are less apt to occur. When Kiellands are used in retropositions and the position is corrected, delivery may take place without further instrumental aid.

Version may be performed with greater ease. The relaxed soft parts permit the insertion of large hands without any difficulty. There is no shock to the mother. Tetanic contractions may be relieved by carrying the anæsthetic higher, as already explained.

In breech presentation (15), especially in old or young primiparæ, the fate of the child is better. Broken arms and legs are less apt to result and delivery can be performed with less effort.

We wish to emphasize the softness and lack of resistance of the cervix and the extreme elasticity of the perineum (19), because it is almost inconceivable until it is witnessed. Slight digital pressure upon the posterior fourchette of the vaginal wall permits dilatation four or five times the normal size. Pituitrin may be used safely if it is given 10 minutes after the spinal anæsthetic, provided obstetrical judgment is used.

The only contra-indication that would appear to this form of anæsthesia would seem to be normal delivery in multiparæ, because these cases usually may be carried through comfortably without deep narcosis.

The question will naturally arise as to whether a 40 per cent novocain solution introduced into the subarachnoid space will cause irritation. This does not occur. Before this solution was used in humans, 6 dogs were injected and secondary taps made 6 hours later. The cell count was no greater than when a 10 per cent novocain solution was used. In fact fewer cells were observed than when a 5 per cent cocain or stovaine solution was introduced into the dural sac. The lack of intradural irritation may be attributed to the fact that the solution remains in a small and dependent portion of the dural sac. Its contact is limited to not more than 1 inch of the extreme tip of the canal as shown by X-rays (Fig. 14) or the lack of irritation may be explained in that novocain itself is not irritating to delicate membranes. The instillation of pure novocain crystals on the human cornea was found to produce little or no irritation. Powdered novocain was applied to the cornea of animals 6 times in one day and no visible inflammatory reaction was produced. The postanæsthetic aspects of the patient have been no different than when a 10 per cent solution was used. Risacher and Waitz have used a 50 per cent solution with no deleterious results.

Since the introduction of starch paste as a controllable feature in spinal anæsthesia, several inquiries as to the solubility of starch or gliadin have been received and likewise as to whether or not the gliadin might act as a foreign body. This can be answered in the negative. Gliadin is extracted from wheat starch through triple 500 mesh silk and rendered soluble before it is added to the anæsthetic solution. A detailed description of the technique of rendering it soluble and the method employed to prevent fermentation would be too long to include in the present paper. When the starch paste was used before gliadin was employed, there were frequent variations in the viscosity of the solution and suspension could not be maintained for more than 20 minutes. With gliadin we are now able to prevent dissemination in the spinal fluid for over 2 hours. The amount of viscosity is constant and reliable, and there is no tendency to variation. The solution will not ferment as sometimes happens with the starch paste. It appears to be permanent and may be kept for at least 1 year without deterioration. We do not know how much longer it can be kept.

The blood pressure is not affected because none of the vasomotor constrictors is anæsthetized. The vasomotors are thrown out from the cord with the spinal nerves from the second dorsal to and including the first lumbar and to those familiar with spinal anæsthesia it is well known that the blood pressure drops in direct ratio to the intensity plus the number of vasomotor constrictors anæsthetized. Stovaine causes the greatest reaction, novocain the least. With controllable spinal anæsthesia, we are able to limit

the upward extent of the solution to any desired height in the spinal canal by regulating the degree of the Trendelenburg position employed as measured by the tiltometer, plus the amount of the expansion of the solution which is obtained by mixing it with the spinal fluid. Four cubic centimeters of spinal fluid mixed with a solution will anæsthetize the lumbar nerves and produce anæsthesia of the perineum and legs, 6 cubic centimeters to the tenth dorsal segment, anæsthetizing the abdomen to the umbilicus. Eight cubic centimeters will carry the solution to the seventh dorsal segment producing anæsthesia to the costal margin, the highest anæsthesia required for abdominal work, only anæsthetizing half of the vasomotor constrictors. Ephedrine employed in an amount proportionate to the height of anæsthesia will stabilize the blood pressure. In sacral anæsthesia no ephedrine is necessary and it is only used as a safe-guard in case the patient should assume a position permitting the anæsthesia to extend upward. When anæsthesia of the lumbar nerves 30 milligrams, to the tenth dorsal 50 milligrams and to the sixth or seventh dorsal 65 milligrams will at all times absolutely stabilize the blood pressure.

Ephedrine is superior to suprarenalin in maintaining the blood pressure because its duration may be depended upon for 2 or 3 hours, or until the anæsthetic has become absorbed and eliminated, whereas the effects of suprarenalin on the vasomotors will not last more than from 15 to 20 minutes and must then be repeated.

The "dreaded" drop in blood pressure does not occur (20). "Dry wounds" are not observed. There is as much bleeding as with inhalation anæsthesia. Respiratory and cardiac embarrassment does not occur. During delivery it is not necessary to administer stimulants. Saline teams are eliminated. If the technique as to the position of the patient, the amount of expansion of the fluid, and the use of ephedrine is observed the patient may be carried through without the slightest drop in blood pressure (Fig. 13). Not infrequently does the blood pressure rise 10, 20, or 30 points.

Braun says that suprarenalin made local anæsthesia possible. That being so, ephedrine has contributed much to the safety of spinal anæsthesia (16). When the blood pressure is maintained, pallor and cold sweats do not occur. Nausea and vomiting are either greatly diminished or eliminated. These facts alone make the operator more at ease and the patient much more comfortable. One author graphically states that the blood settles to the dependent parts of the body when spinal anæsthesia is used and that the radial pulse has no clinical significance because of the relaxed condition of the arterioles and because the impulse of the heart beat is not carried to the wrist (14); in other words the patient is pulseless. If Babcock (3) or Boyd (4) who together have administered spinal anæsthetics 47,000 times, saw a patient in a pulseless condition they would be greatly alarmed. To the inexperienced or to the one using spinal anæsthesia for the first time, it would undoubtedly give such a fright that he would permanently abandon it.

A report of several cases of controllable spinal anæsthesia by operators in various parts of the country unknown to each other and many of them personally unknown to the authors, who have used this form of anæsthesia independently, would seem to be more convincing than words. Table I deals only with the heretofore dreaded complications of spinal anæsthesia.

SUMMARY

In conclusion we do not wish to insinuate that spinal conduction or local anæsthesia should always be employed, but past experiences have taught us that with their use we do not encounter the troublesome postoperative anæsthetic after-effects, such as, nausea, vomiting, gas distention, ileus, acidosis, pneumonia, and innumerable other complications, which are directly caused by inhalation anæsthesia. The primary mortality is undoubtedly less, whereas the secondary mortality (8), or in other words the mortalities that occur from one day to one week following operation and which are due directly to inhalation narcosis, are practically nil. Morbidity is reduced to a minimum. Since spinal anæsthesia has been developed to the point of safety which it now enjoys, the technique of induction has been so perfected that with these anæsthetics we are able to perform any operation upon the human body with greater facility and offer better protection to the patient. Today, patients are not to be classed with those of a decade ago. They have been educated and enlightened not only as to anæsthetics but as to obstetrics, surgery, and medical procedures in general through public health movements, societies, and the press. Their knowledge must be respected. Therefore, we should perfect ourselves in the technique of spinal conduction and local anæsthesia so as to be able to meet the demands of the public.

For the development of this anæsthesia in the future we will have to look chiefly to the younger men. Twenty years ago spinal and local anæsthetics were rarely used. Today they are rather

popular and are being more and more generally used. Spinal conduction and local anæsthesia will undoubtedly increase in popularity in the next 10 years.

BIBLIOGRAPHY

1. Abadie et al. Intraspinal anæsthesia and uræmia. Presse méd. 1926, xxiv, 387.
2. Astley, B. G. M. Spinal anæsthesia in cæsarean section for toxæmia of pregnancy. Am. J. Obst. & Gynec., 1927, xiii, 83–86.
3. Babcock, Wayne W. Blood pressure in relation to spinal anæsthesia. Anesth. & Anal., 1925, iv, 222.
4. Boyd, August S. "We have not had more than a 30 or 40 point drop in blood pressure or had occasion to administer stimulation on the table in over 3 years." Personal communication.
5. Brindeau and Lantuéjoul. Spinal anæsthesia in obstetrics. Bull. Soc. d'obst. et de gynéc. de Par., 1927, xvi, 243–245.
6. Brooks, J. D. Spinal anæsthesia in tuberculosis patients. U. S. Vets. Bur. Med. Bull., 1927, iii, 700.
7. Campbell, Meredith F. Spinal anæsthesia. Ann. Surg., 1926, lxxxiv, 42–50.
8. Idem. Spinal anæsthesia: a study of its use in 536 cases. Anesth. & Anal., 1927, vi, 75–80.
9. Cooke, Harry Theodore. Spinal analgesia in obstetrics including cæsarean section; or painless conscious childbirth. Am. J. Surg., 1923, xxxvii, 107–111.
10. Delmas, P. Concerning spinal cocainization in operative gynecology and obstetrics. Rev. franç. de gynéc. et d'obst., 1920, xv, 145–154.
11. Desplas and Millet, P. The "shock producing" reputation of spinal anæsthesia. Is it justified? Presse méd., 1918, xxvi, 234–236.
12. Jeanbrau, E., Cristol, P., and Bonnet, V. Anæsthesia and acidosis. J. d'urol., 1921, xi, 505. Abstracted in J. Am. M. Ass., 1921, lxxvi, 1200.
13. Kroenig, W. Lumbar anæsthesia and gynecological laparotomies. Zentralbl. f. Gynaek., 1925, xlix, 696–702.
14. Labat, Gaston, Circulator disturbances associated with subarachnoid block. Long Island M. J., 1927, xxi, 573–579.
15. Lantuéjoul. Spinal anæsthesia in obstetrics. Gynéc. et obst., 1924, ix, 384–386.
16. Ockerblad, Nelse F., and Dillon, T. G. The use of ephedrine in spinal anæsthesia. J. Am. M. Ass., 1927, lxxxviii, 1135.
17. Oldham, P. S. Further experiences and results with sacral anæsthesia in obstetrics. Anesth. & Anal., 1927, vi, 192–196.
18. Pitkin, George P. Controllable spinal anæsthesia. J. M. Soc., New Jersey, 1927, xxiv, 425–438.
19. Risacher, S. E., and Waitz, R. Spinal anæsthesia limited to the perineal region by the use of a concentrated solution of novocain. Bull. Soc. d'obst., et de gynéc., 1927, xvi, 41–42.
20. Sise, Lincoln F. The use of ephedrine in spinal anæsthesia. Surg. Clin. N. Am., 1928, viii, 195–200.
21. Sise, Lincoln F.; Kelley, Frank A.; Wethereli, Frederick S. Personal communication.
22. Smith, G. G., and Porter, W. T. Spinal anæsthesia in the cat. Am. J. Physiol., 1915, xxxviii, 108–127.
23. Vandesial, R. Spinal anæsthesia in obstetrics. Bruxelles méd., 1923, xxv, 845.
24. Williams, J. Whitridge. The toxæmias of pregnancy and the treatment of eclampsia. J. Am. M. Ass., 1927, lxxxviii, 449–454.
25. Yount, Carl C. Spinal anæsthesia. Surg., Gynec. & Obst., 1917, xxv, 40–45.

THE IMPORTANCE OF EARLY TRACHEOTOMY

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TRACHEOTOMY is a word which has long been associated in our minds with exhaustion, pneumonia, cardiac failure, and death. This association is, we feel, unwarranted and is due to the fact that in the rare case in which the operation is necessary the results are unfavorable because operation is usually deferred too long rather than because of any intrinsic fault in the operation itself. When performed early, tracheotomy is very much more effective as a strength-conserving and life-saving measure than when it is used as a last resort.

One of the most valuable uses of tracheotomy is to relieve laryngeal obstruction which may follow an operation on the thyroid gland, and it is to this type of case that we have particular reference in this paper. The obstruction in such a case may be due to bilateral abductor paralysis, either temporary or permanent, when the vocal cords are approximated in the midline; or it may be due to œdema of the larynx or to deep cervical hæmorrhage. Other conditions which sometimes necessitate tracheotomy are carcinoma of the larynx and of the thyroid and deep cervical infections.

The obstruction may occur during operation or at any time after it, but, it almost never occurs after more than 60 hours. When obstruction occurs during operation, it is generally due to posture and to traction on the gland. If that is the case, it will clear up very shortly upon relief of the causative factor. In the rare cases in which obstruction develops months or years after operation, it is due to involvement of the

recurrent laryngeal nerve in the scar tissue and in such cases the prognosis is very poor.

The characteristic sign of nearly all types of laryngeal obstruction is inspiratory stridor, which is more pronounced when the patient is sleeping. If it is of any considerable degree, the patient complains of difficulty in getting sufficient air and uses the accessory muscles of respiration. The facies is anxious and often large doses of morphine fail to induce sleep. Tachycardia and weakness of the pulse may appear early, but generally they are late symptoms, especially in a calm patient with some reserve strength. Cyanosis is generally of serious significance and except in cases in which an almost complete obstruction develops quickly, it is an indication that the partial obstruction has been present for a considerable length of time and that relief should have been given earlier. A strong voice, which, however, is monotonic, is often present and may be misleading. Examination of the larynx will generally reveal the cause of the obstruction. If it is due to bilateral abductor paralysis, the cords will be seen to be approximated in the midline.

The complaint of the patient is the most important indication for a tracheotomy. A slight obstruction which is borne with ease by most patients, may be a serious burden to a very weak and nervous one. If the cords are seen to be fixed in the midline a tracheotomy should be performed at once. If the obstruction is of slight degree and if there is some space between the cords, it is justifiable to defer the operation for several hours in the hope that it will not be necessary. In this connection, however, it should be emphasized that delay is especially dangerous if the patient has little reserve strength. If there is any doubt it is much safer to perform the tracheotomy, as the tendency is for laryngeal obstruction to increase, once it has developed to any degree. This tendency to increase is accounted for by the increasing congestion and œdema. Many cases may clear up by the use of an oxygen tent but they should be watched very closely and if any signs of an early exhaustion are present, an immediate tracheotomy should be done.

One of the fundamentals of present day surgery is to conserve the strength of the patient and it is just this which early tracheotomy does; for when the operation is performed early, the general condition of the patient has not become impaired by a long fight for sufficient oxygen, the mental condition is clear, and the patient is able to co-operate; the cough reflexes are present and are not deadened by fatigue and by large amounts of morphine; and there is also a minimum of mucus in the bronchi. Another advantage is that the operation can be better and more safely performed since great haste is unnecessary.

In contrast to this is the picture seen when tracheotomy is performed late. The patient is exhausted and often cyanotic and the pulse is weak; the bronchi are full of mucus and the patient is unable to cough after the tracheotomy has been performed. Not infrequently so much morphine has been administered that artificial respiration is necessary after operation. There is considerable evidence to show that a long continued laryngeal obstruction predisposes to massive pulmonary atelectasis. The operation is technically more difficult, since it must often be done in haste, and because the patient is unable to co-operate. Moreover, respiration not infrequently ceases entirely as soon as the neck is extended to expose the trachea.

The one objection to early tracheotomy is that occasionally the operation may be performed unnecessarily. However, this is rarely the case, for, as we said before, the tendency is for laryngeal obstruction to increase and even should tracheotomy be performed unnecessarily, very little harm will have been done. The tube can be removed in several hours and the opening closed, while the time necessary for the wound to heal will be but little prolonged. On the other hand, in the rare cases in which the operation appears to be indicated and the tracheotomy is postponed in the hope that it will be unnecessary, the morbidity and mortality are greatly increased.

In a subsequent communication the technique of tracheotomy and the after-care of the patient will be described.

EDITORIALS

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CHRONIC SUBDURAL HÆMATOMA

CHRONIC subdural hæmatoma is an intracranial lesion closely simulating a neoplasm in its manifestations. Usually it is the direct result of a head injury, although in the majority of cases a history of trauma is difficult to elicit.

With the advent of the mechanical era, which developed the fast train, the motor car, and the aëroplane, traumatic surgery has left the hands of the industrial surgeon and has become more a part of the work of the general surgeon and the general practitioner. Head injuries, either fractures of the skull or concussions, demand immediate attention, often necessitating hospitalization, and are classified as emergencies. However, the sequelæ of such injuries often require more careful study and consideration.

Chronic subdural hæmatoma may manifest itself at any time from 5 weeks to 10 months subsequent to the accident and its onset is so insidious and its symptoms so protean that it is difficult to distinguish it from intracranial neoplasm. Many times the symptoms are merely those of increased intracranial pressure without localizing signs, and coma may supervene to complicate the clinical picture.

Chronic subdural hæmatoma is now being observed more frequently and is being operated on in the early stages with excellent results. Sometimes the history is baffling, and on casual examination a deep-seated intracranial neoplasm may appear to be present. A careful history and thorough examination should elicit (1) a history of head injury, either slight or severe, followed by an interval free from symptoms, and the insidious development of increased intracranial pressure; (2) papillœdema or a field defect, and (3) sensory or motor impairment which might indicate the site of the lesion. If the site of the lesion has been determined, exploratory craniotomy is indicated and the hæmatoma can be removed completely. Certain writers consider the advisability of drainage, but statistics show that complete closure is just as successful and avoids the added danger of secondary infection.

From a surgical standpoint, chronic subdural hæmatoma is spectacular. Its presence is signified by a pigmented overlying dura which, on incision, reveals what appears to be an organized blood clot in the subdural space; however, it differs from pachymeningitis hæmorrhagica interna in that its surface has not the laminated appearance so characteristic of this condition. On palpation, it usually fluctuates, and, within the capsule, there is fluid of different color and consistency depending on the duration of the lesion. When aspirated, this fluid resembles bile and after the cavity has been evacuated, the capsule can be stripped away from the underlying pia arachnoid leav-

ing normal-appearing compressed cortex beneath.

Pathologically, the lesion is an organized blood clot whose center has liquefied and whose capsule shows fibrous organization interspersed with mesothelial cells which have invaded it ostensibly from the meninges. These mesothelial cells have been classified as a part of the reticulo-endothelial system of cells and closely allied to the Kupffer cells of the liver, while the fluid contained within the hæmatoma corresponds to biliverdin and bilirubin resulting from the reaction of the mesothelial cells on the hæmoglobin contained within the structure. Virchow's classic description of the lesion in 1857 has continued to remain outstanding, and his conception of the etiology and the relation to the surrounding tissues remains undisputed.

Because of the unequivocally successful results of operative procedures in cases of chronic subdural hæmatoma, such a lesion should be considered as a possibility in the differential diagnosis of intracranial complication. WINCHELL MCK. CRAIG.

CONVULSIONS

CONVULSIONS have puzzled the wits of men for ages. They may be associated with certain diseases, with injuries, or with intoxication from drugs. Uræmic convulsions from urinary obstruction may be relieved by surgical measures. Care of expectant mothers may do much to prevent convulsions arising from the toxæmia of pregnancy, and care during parturition will do much to prevent injury to the child which may lead to convulsions. Neurosurgery has something to offer for the relief of convulsions associated with brain tumors, abscesses, and injuries. There are, however, certain convulsive seizures that defy treatment or explanation. These are referred to as "idiopathic" and should mark the frontier of research on the problem of epilepsy. Various hypotheses with regard to the etiology have been applied to idiopathic convulsions, one of which is heredity. It has been inferred that natural phenomena explain such manifestations, inasmuch as some animals (the opossum and certain beetles) display similar behavior in defense. Psychogenesis has been used as an explanation, as well as unknown toxic agents supposed to arise in the course of metabolism. The endocrine glands have been suspected. There may be elements of truth in all hypotheses, but from them there is little to offer the patient. The etiology is elusive and obscure.

Certain clinical and experimental observations of the last decade or two may throw light on the problem. Dandy has demonstrated on dogs that injury to the motor cortex lowers the threshold for the production of convulsions. To produce seizures in dogs so injured only from one-third to one-seventh of the dose of absinthe was necessary, as compared with normal animals used as controls. From Dandy's work it might be implied that injury to the motor cortex is probably fundamental in the cause of convulsions.

It has been found that convulsions may be induced when the blood sugar is reduced to a low level by an overdose of insulin. Wilder, Allen, and Robertson report the case of a man who became unconscious when he became hungry. If he was not relieved by the ingestion of sugar or candy, convulsions developed. The blood sugar was extremely low during unconsciousness. He became progressively weaker and died. At necropsy it was found that carcinoma of the islands of Langerhans had metastasized to the liver and lymph nodes. Extracts of the metastatic growths injected intravenously into a rabbit

caused marked reduction in its blood sugar. In another case a young, slender, rapidly growing high-school girl, for cosmetic and athletic purposes, abstained from eating a sufficient amount of food, and light convulsions developed when she awakened in the morning. The blood sugar was low. She was given a lump of sugar each morning on awakening, together with sufficient food during the day, and the convulsions disappeared.

There are various ways in which diet has been regarded as a factor in health and disease. The importance of the ketogenic diet for the relief of convulsive seizures, especially in childhood, is attracting much attention. Beri-beri, a disease of the nervous system, seems definitely traceable to dietary deficiency. Pellagra and pernicious anæmia, both diseases in which the nervous system may be affected, have been regarded as deficiency diseases; they respond somewhat to dietary treatment. From the standpoint of diet, probably no observations are more significant than those of Hughes who reports a disorder of the nervous system invariably produced in young pigs, by a diet free from vitamine A. The syndrome consists chiefly of ataxia, blindness, paralysis, and convulsions. Only partial recovery takes place when the diet is corrected.

Hughes' work suggests the effect on the brain of the fetus if the mother does not get enough of vitamine A by reason of the season, locality, capriciousness of appetite, or hyperemesis gravidarum. But even if the child fares well before birth, and is not injured at birth, in early childhood his brain may have to endure, for various reasons, the insult of improper food and through life suffer the defect. Thom found that convulsive seizures began before the age of four in 51 per cent of epileptic cases. He quotes from Elliot, who found that fewer convulsions developed in cases of rickets treated early than in those untreated.

In summarizing it may be said that idiopathic epilepsy is probably due to injury to the brain which enables smaller insulting agents to induce convulsions. Injury probably occurs early in life and must be insidious and obscure to escape detection. In the light of recent work on vitamine deficiency the health of expectant mothers and the food of children should be given every consideration to prevent the type of injury to the brain that never can be repaired.

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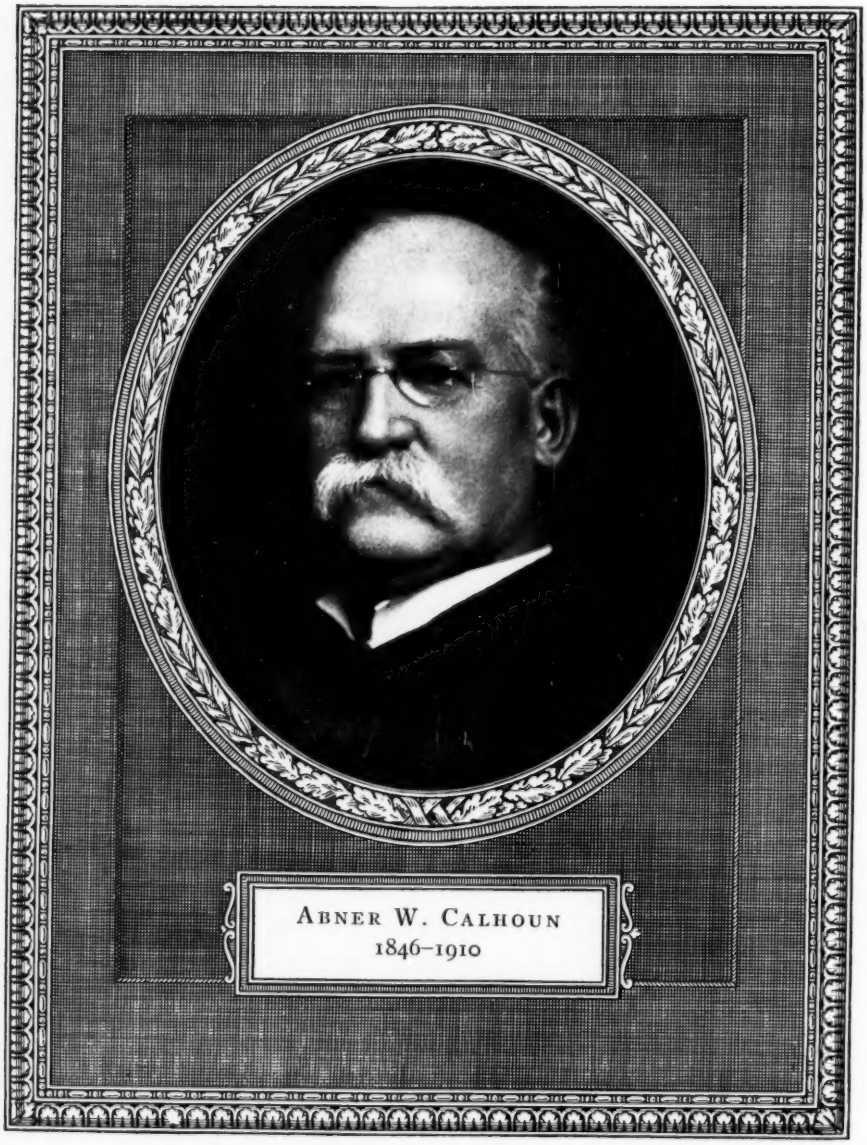
BIBLIOGRAPHY

1. DANDY, W. E. Experimental investigations on convulsions. J. Am. M. Ass., 1927, lxxxviii, 90–91.
2. HUGHES, J. S. Relationship of vitamin A to nervous disorders. (Unpublished data.)
3. THOM, D. A. Infantile convulsions: their frequency and importance. Am. J. Psychiat., 1927, lxxxiii, 613–622.
4. WILDER, R. M., ALLAN, F. N., POWER, M. H., and ROBERTSON, H. E. Carcinoma of the islands of the pancreas. J. Am. M. Ass., 1927, lxxxix, 348–355.



ABNER W. CALHOUN
1846–1910

UNIV OF MICH.

MASTER SURGEONS OF AMERICA

ABNER WELLBORN CALHOUN[1]

IT is altogether fitting and proper that the memory of Dr. Calhoun should be enshrined in the Abner W. Calhoun lectureship foundation. His achievements as citizen, soldier, physician, and teacher constitute a distinguished chapter in the chronicles of the history of this great state and add luster to the records of many other notable accomplishments of which you are justly proud.

Dr. Calhoun was fortunate in his parentage and the guidance thus bestowed, and the register of the events of his life portrays the unfolding and development of his sterling character and his resolve "to do the work in hand with scrupulous and unaffected dignity, freely and justly."

Introduced by his father to the study of medicine, he matriculated in the Jefferson Medical College of Philadelphia and was graduated as the honor man of his class, well nigh 60 years ago. Especially interested in the study of anatomy in his student days, he continued that interest when he went abroad shortly after his graduation. Attracted by the eminence of Hertel, he spent all available hours in his dissecting room, where, indeed, for a time he was his prosecutor. During this period he was offered the chair of anatomy in the Atlanta Medical College. How better could he have laid the foundation for his future career as a notable exponent of one department of special surgery, wherein he was destined to attain a prominent place, than by acquiring proficiency in this important fundamental branch of the medical sciences.

Doubtless influenced by his father, he realized the necessity of gaining specialized knowledge and experience in ophthalmology and otolaryngology, and with characteristic energy and ambition sought and obtained instruction in the clinics of the masters of those days in these departments of medical and surgical work.

Fully and admirably equipped, he returned to his own home and was elected professor of ophthalmology and otolaryngology, in the Atlanta Medical College, of which his father had been one of the founders. He continued with praiseworthy ability to fulfill the duties of this distinguished post until the day of his death, serving not alone as teacher, but as administrator, and in all the ways he was able admirably strove for its development and improvement.

[1] Adapted from the introduction to the lecture delivered before the Medical Association of Georgia under the auspices of the Abner Wellborn Calhoun Lecture Foundation.

His success was immediate and there gathered about him an extensive clientele, the most extensive this Southland has ever known. From far and wide his patients came seeking the help of his clinical and his operative skill, and no one, rich or poor, sought this benefit in vain.

His commanding presence, his distinguished personality, his utter friendliness, his high ideals, his balanced judgment, his untiring energy, his manual dexterity —these were the assets of this gifted man, spent with fine liberality for the advantage of his adoring patients and of his admiring students.

His was the hand which restored to countless hundreds the priceless heritage of sight. He lived his life abundantly. Of him it may be said, as it has been said of another great physician, "the very name of him was Victory."

Deeply concerned with the obligations and responsibilities of medical and surgical practice, he none the less found time to accept and faithfully to perform the duties which pertain to organized medicine, to teach to the eminent satisfaction of his students, to contribute liberally and efficiently to the literature of the Department of Medicine and Surgery he so well adorned, to engage effectively in public affairs, and to be an outstanding citizen imbued with the spirit of civic righteousness and of business rectitude.

He was a great physician and a great gentleman. He belonged to that rare group of men who find hidden joy in every perfect service and who give fine example of the conduct of the higher life.

In my early days, long ago, it was my privilege to visit Dr. Calhoun. This was a happy circumstance in my life. The impressions then gained have never failed. I am honored in the opportunity of paying him tribute, albeit inadequately framed and spoken, but I pay it reverently and in that reverence I know you join.

I quote some recently published lines, somewhat altered in their relations, and yet appropriate:

> And when he walked, his was the stride of one
> Who lives a tireless servant of his land.
> He knew that land and held its honor high.
> There was no cedar tree in all his wood
> More finely straight than he.
> He cannot be forgotten by his own.

G. E. DE SCHWEINITZ.

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

By ALFRED BROWN, M.D., F.A.C.S., Omaha, Nebraska

THE SUCCENTURIATUS ANATOMICUS OF PIETER PAAW

THE mystical superstition that the brain is the home of the human mind and soul has been handed down since the dawn of time. Evidence of this belief is found in the skulls showing healed trephine openings which have been found in prehistoric burial places in many lands, the widely separated countries from Peru to France and Japan to Portugal showing the general prevalence of the idea. Naturally we cannot be positive that these early skull operations had to do with such a belief, but if we start from the premise that this was the idea of the early trephining operations of which we have knowledge and reason from this, it seems fair to assume that they were performed for some abnormality that had to do with the psychic rather than the physical side of the patient. Broca suggested that in addition to the superstition that the ego resides in the brain there was also a religious element in the operation so that it partook of the nature of a religious ceremony. The patient, when and if he recovered, became exalted to the status of a holy individual. Later, demonology appeared and played its part in human philosophy. An insane man was presumed to be possessed of devils which had their dwelling place in the brain. Again the trephine came into use as a means of liberating devils. These various theories called attention to the brain as the most important element in the human make-up.

Such a condition of affairs brought the diseases and injuries of the skull and brain into a position of great importance and made them a most alluring subject for the surgeon who happened to be somewhat philosophically inclined. Hippocrates devoted himself to this specialty of medicine and left his treatise on *Injuries of the Head*, in which, however, as shown by the title, he confines himself to trauma alone. After Hippocrates, nearly every surgeon who wrote anything at all had something to say on the subject of head injuries, but little new was offered until Berengarius published his treatise in 1518.

Pieter Paaw was born in Amsterdam in 1564 and took up the study of medicine when he was only 16 years of age, beginning at the University of Leyden. Upon the completion of his course, he took up post-graduate work in the famous schools at Paris, Orleans, Rostock, and Padua, until he was called back to Amsterdam by the illness of his father. At these various schools he came in contact with many of the great men of the day: Heurnius, Bontius, Justus Lipsius, Dodeneus, Bruscæus, and Fabricius of Acquapendente. By the time he reached Paris he had evidently made up his mind to devote himself to anatomy as his main objective for he continued that study both in Rostock, where he gained his doctorate in his twenty-third year, and in Padua.

Upon his return to Holland, he became the professor of anatomy and Botany at the University of Leyden. Holland lagged behind the other countries that Paaw had visited in that anatomy was still considered as a theoretical subject and part of philosophic medicine. Paaw evidently changed the custom, for we find that in 1597 the University built an anatomical theater and the following year the government of Holland granted to the professor of anatomy the right to dissect the human body. Of this privilege Paaw took advantage and in 22 years dissected 60 human and many animal bodies.

Though Paaw's writing was largely along the line of anatomy and his principal works *Primitiæ anatomicæ*, *First Fruits of Anatomy Concerning the Bones of the Human Body* in 1615 and his re-editing of the *Epitome* of Vesalius, in 1618, were purely anatomical; he did apply his anatomical research to the subject of fracture of the skull and published his book on the subject in 1618. He bases this work on Hippocrates' *Wounds of the Head* and the first four chapters of the eighth book of Aurelius Cornelius Celsus upon the diseases and injuries of the bones and joints.

In this work Paaw has applied his knowledge of anatomy, both normal and abnormal, to explain the diseases of which Hippocrates and Celsus write, and adds his own commentaries in correction of errors where he thinks it necessary. The most striking part of the book is the collection of copper plates which he uses to illustrate the various forms of lesion of the skull and the instruments used in cranial surgery. These are evidently the work of a master engraver, for they are beautifully done and, due evidently to Paaw's careful direction, are in great measure correct.

It would hardly be fair to dismiss the *Succenturiatus Anatomicus* without calling attention to the copper plate portrait of the author which shows him as a typical Hollander, neck ruff and all, who may have posed for one of the heads in a painting by Rembrandt or Frans Hals.

REVIEWS OF NEW BOOKS

EVERY student of medicine must at frequent intervals become aware of the fact that there is a relatively large group of patients who complain of dyspeptic symptoms, not typically ulcer or gall bladder in type but equally distressing and disabling. The laboratory methods of diagnosis offer little diagnostic assistance. Many of these patients have been subjected to a cholecystectomy or an appendectomy and in not a few cases the symptoms have remained unabated and not infrequently have been aggravated. These unfortunate patients are usually termed "neurasthenics" and are cast loose to fall into the hands of some cult or, what is even worse, into the hands of an unscrupulous surgeon who begins a series of operations, which are planned without reason or conscience. The fault must be laid at the doorstep of the medical profession because of the lack of interest and perhaps lack of painstaking and judicious study of the gastro-intestinal tract. The duodenum, of which so little is known, has been almost uniformly conceded to have but one noteworthy disease, viz., ulcer. From time to time pertinent articles to the contrary have found their way into the literature but it seems that their importance has not been heeded by the profession.

Some years ago the reviewer became interested in the study of duodenal obstruction and allied conditions, and it is therefore most gratifying for him to be allowed to pass judgment on the recent translation by Quain of the little monograph on the duodenum by Duval and his associates.[1] What is said of duodenal compression, its diagnosis, symptoms, and treatment can be heartily subscribed to. Furthermore the authors' description of "Essential and Stenosing Periduodenitis" is accurate and pertinent and must be considered seriously by the profession. Their description of the deformed duodenum due to adhesions which enmesh it, is most interesting and conforms to the reviewer's opinion. The symptoms are not pathognomonic but suggestive. It finally becomes the task of the roentgenologist to confirm the diagnosis. There is no question but that the roentgenological studies of the gastro-intestinal tract must be conducted with intelligence and interest and not as a stereotype procedure, ground out, *en masse*, by a technician and hastily interpreted by the roentgenologist who sees one thing and thinks of another. So long as such studies continue, no advancement will be made. The authors lay great stress upon carefully conducted roentgenological studies of the duodenum, special care being used to observe its size, shape, position in relation to the stomach, its emptying time, reverse peristalsis, contour with character of the deformity, and the like. From these observations they have been able in many instances to differentiate intrinsic disease of the duodenum from periduodenal adhesions and bands causing compression and deformity with stasis.

This small work is intensely interesting and should be read by every practitioner of medicine. In no single small volume can so much startling and valuable information be found, information which is of vital importance to the practitioner. The authors deserve much credit for presenting their observations to the profession and honor is due to Quain for placing in our hands an excellent translation of a much needed work. JOHN A. WOLFER.

THIS small manual of surgical anatomy[2] by Whittaker is a well printed text illustrated with somewhat over a hundred well chosen diagrams and drawings.

While it is not so extensive as many books of a similar nature, its brevity results rather from careful phrasing than from omission of important subject matter. One gains the impression that the book represents a competent teacher's selection of essential anatomical data culled from years of experience. The subject matter is taken up in the traditional English form, and one can recognize the influence of Cunningham on almost every page. The book is hardly one for the beginning medical student but can be sincerely recommended to the surgeon and clinical teacher. MICHAEL L. MASON.

THIS small volume on postmortem appearances[3] was written by Dr. Joan M. Ross, senior assistant pathologist to the Royal Free Hospital, and lecturer in pathology in the London School of Medicine for Women. The author's object was to "describe the chief anatomical changes found in the commoner diseases," but it was not intended that this description should take the place of practical experience. "The general practitioner, who may be called upon to make an occasional autopsy, will find it a useful guide as to what he should look for. And the student who habitually consults it in the postmortem room will be able to tell, with the least possible trouble, whether the case before him conforms to type, or how it is abnormal." With these limitations definitely in mind, Dr. Ross has produced a book that will be useful to those for whom it is intended.

In an introductory chapter, the author discusses the characteristic appearances after death from asphyxia, from syncope, and in coma; the technique of performing a postmortem examination; and the methods of preserving specimens for histological examination and for museum use.

Throughout the remaining sections of the volume, a definite order is rather rigidly followed. First, the

[1] THE DUODENUM; MEDICAL, RADIOLOGIC AND SURGICAL STUDIES. By Pierre Duval, Jean Charles Roux, and Henri Béclère. Translated by E. P. Quain, M.D. St. Louis: The C. V. Mosby Company, 1928.

[2] A MANUAL OF SURGICAL ANATOMY. By Charles R. Whittaker, F.R.C.S. (Edin.), F.R.S.E. 4th ed. rev. and enlarged. New York: William Wood Company, 1928.

[3] POSTMORTEM APPEARANCES. By Joan M. Ross, M.D., B.S. (Lond.), M.R.C.S., L.R.C.P., with an introduction by E. H. Kettle, M.D. New York and London: Oxford University Press, 1928.

external appearances of the body are described. As an example, the following under "Gastric Carcinoma" may be cited:—"External Appearances. The body is that of a man between 40 and 60 years of age. There is anæmia, with a yellowish tinge of the skin; sometimes jaundice may be present. Emaciation may be extreme. There may be swelling of the ankles. Secondary nodules of growth may be present in the skin of the abdominal wall." After such a brief summary of the more common external findings, the internal appearances are considered by systems of organs. The lesions found in different diseases are named rather than described, as, for example, cloudy swelling, fatty degeneration, infarction, etc. Inasmuch as the description of these conditions can be readily found in the usual textbooks of pathology, the brevity which this method permits is probably a gain in that it avoids the confusion incident to too much detail. At the end of the volume are five appendices giving the average normal sizes and weights of organs; the length and weight of a fetus at different stages of gestation; the approximate weight of the organs of a newborn child; the dates of ossification of the principal bones; and the ages of eruption of the teeth.

This volume is pocket-sized, well bound, and printed on good paper without gloss. The typography is clear, and the headings of paragraphs are so arranged that they readily indicate the co-ordination of the divisions of the subject being discussed. This book will not be of any particular interest to one who has had an extensive experience in post-mortem examinations, but to those for whom it was primarily intended, it will serve as a clear, brief and, on the whole, accurate guide to the proper performing of an autopsy. J. P. SIMONDS.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

BIOLOGIE UND PATHOLOGIE DES WEIBES; EIN HANDBUCH DER FRAUENHEILKUNDE UND GEBURTSHILFE. By Josef Halban and Ludwig Seitz. Lieferung 44. Berlin and Vienna: Urban & Schwarzenberg, 1928.

PRACTICAL SURGERY OF THE ABDOMEN. By George H. Juilly, M. D. Foreword by W. Wayne Babcock, M.D. Vols. i and ii. Philadelphia: F. A. Davis Company, 1928.

PREVENTIVE MEDICINE. By Mark F. Boyd, M.D., M.S., C.P.H. 3d ed. rev. Philadelphia and London; W. B. Saunders Company, 1928.

AN INTRODUCTION TO EXPERIMENTAL PHARMACOLOGY. By Torald Sollmann, M.D., and Paul J. Hanzlik, M.D. Philadelphia and London: W. B. Saunders Company, 1928.

A TEXT-BOOK OF FRACTURES AND DISLOCATIONS COVERING THEIR PATHOLOGY, DIAGNOSIS, AND TREATMENT. By Kellogg Speed, S.B., M.D., F.A.C.S. 2d ed. enlarged and rev. Philadelphia: Lea & Febiger, 1928.

REQUISITES AND METHODS IN SURGERY; FOR THE USE OF STUDENTS, HOUSE SURGEONS, AND GENERAL PRACTITIONERS. By Charles W. Cathcart, C.B.E., and J. N. Jackson Hartley, O.B.E. Edinburgh and London: Oliver & Boyd, 1928.

BULLETIN OF THE NATIONAL RESEARCH COUNCIL. The Coroner and the Medical Examiner; Issued under the Auspices of the Committee on Medicolegal Problems. By Oscar T. Schultz and E. M. Morgan. With a Supplement on Medical Testimony. By E. M. Morgan. Washington: The National Research Council of The National Academy of Sciences, 1928.

DISEASES OF THE EAR, NOSE AND THROAT; MEDICAL AND SURGICAL. By Wendell Christopher Phillips, M.D. 7th ed. rev. Philadelphia: F. A. Davis Company, 1928.

SURGICAL DIAGNOSIS IN TABULAR OUTLINE; FOR STUDENTS AND PHYSICIANS. By Dr. A. J. Cemach. Authorized Translation, with Additions and Notes. By Edward L. Bortz, M.D. With an Introductory Note. By John B. Deaver, M.D. Philadelphia: F. A. Davis Company, 1928.

A PRACTICAL MEDICAL DICTIONARY. By Thomas Lathrop Stedman, A.M., M.D. 10th ed. rev. New York: William Wood & Company, 1928.

INTERNATIONAL CLINICS; A QUARTERLY OF ILLUSTRATED CLINICAL LECTURES AND ESPECIALLY PREPARED ORIGINAL ARTICLES ON TREATMENT, MEDICINE, SURGERY, ETC. Edited by Henry W. Cattell, A.M., M.D., with the collaboration of others. Vol. iii, 38th series, 1928. Philadelphia and London: J. B. Lippincott Company, 1928.

RECENT ADVANCES IN SURGERY. By W. Heneage Ogilvie, M.A., M.D., M.Ch., (Oxon.), F.R.C.S. Eng. Philadelphia: P. Blakiston's Son & Co., 1928.

A TEXT-BOOK OF SURGERY; FOR STUDENTS AND PHYSICIANS. By W. Wayne Babcock, A.M., M.D., F.A.C.S. Philadelphia and London: W. B. Saunders Company, 1928.

ANNALS OF ROENTGENOLOGY; A SERIES OF MONOGRAPHIC ATLASES. Edited by James T. Case, M.D. Vol. vii.—Urological Roentgenology. By Hugh H. Young, M.D., and Charles A. Waters, M.D. New York: Paul B. Hoeber, Inc., 1928.

SINUS THROMBOPHLEBITIS; INFLAMMATORY DISEASES OF THE VENOUS SINUSES OF THE DURA MATER. By Alfred Braun, M.D. New York: Paul B. Hoeber, Inc., 1928.

AN INDEX OF DIFFERENTIAL DIAGNOSIS OF MAIN SYMPTOMS BY VARIOUS WRITERS. Edited by Herbert French, C.B.E.(Military), M.A., M.D. (Oxon.), F.R.C.P. Lond. 4th ed. New York: William Wood & Company, 1928.

DIAGNOSTISCHE UND THERAPEUTISCHE IRRTUEMER UND DEREN VERHUETUNG; CHIRURGIE. Edited by Prof. Dr. J. Schwalbe. Vol. ix. Leipzig: Georg Thieme, 1928.

AMERICAN COLLEGE OF SURGEONS

INAUGURAL ADDRESS

THE EVOLUTION OF CLINICAL MEDICINE AND SURGERY IN RELATION TO THE PRESERVATION OF HEALTH AND LIFE[1]

By FRANKLIN H. MARTIN, M.D., President, Chicago, Illinois

I. Introduction

NO greater honor can come to a surgeon than to have conferred upon him the presidency of the largest and one of the most influential surgical organizations of the world—the American College of Surgeons. My friends, from the bottom of my heart I thank you for this distinction, though I must confess I consider myself unworthy to occupy a position of such responsibility.

In my address I shall attempt to portray the present evolution of the ART and SCIENCE of medicine, and the part that our profession and the public should have in guiding its successful progress; I shall review the efforts the American College of Surgeons has put forth and will, I trust, continue to put forth, to aid progressive co-operation between the profession and the public in this important movement—the preservation of health, and the increased happiness of humanity.

II. The American College of Surgeons

Those who visualized the American College of Surgeons, organized it, and have been responsible for its administration, realized from its inception that just to organize another surgical association, just one more academic society, was not a reason to warrant its creation. The College, to justify its existence, would have to assume the responsibility of building for broader science, for more worthy practice, for interest in sustaining the traditions of the greatest profession; and by the example of its Fellows and through open discussion, impress upon the public the significance of scientific medicine as THE ONE AUTHORITY qualified to maintain the health, and insure the wholesome living of all people.

III. Our Creed

It was a bold announcement—the declaration by the Founders of the College at its inception, that not only would the standard of surgery be elevated, but the public would be admitted into the confidence of the profession, and the aid of the public solicited to accomplish the ambitious program of the College. Conservatism and conventionalism, within and without the profession, asked in astonishment: "Is it possible that this group of men is actually serious in advocating so revolutionary a program?"

On this, the fifteenth anniversary of the existence of the College, I venture that the profession and the laity in the United States and Canada are prepared to answer that query in the affirmative, and to acknowledge that the American College of Surgeons is fully justified in assuming that its leadership is recognized, not only as progressive, but safe.

IV. The Authority of Scientific Medicine

Among the learned professions, medicine has no equal in longevity, in continuity, in ideality, in disinterested service, and in accomplishments. For twenty-five centuries, medicine exhibits a clear history. Its spiritual and moral creed—the Hippocratic Oath—announced at that early beginning, has been and is as fundamental in the guidance of the true physician as the Sermon on the Mount (first uttered five hundred years later) in the guidance of the true Christian. Spiritually, morally, and scientifically, in all civilized countries scientific medicine is outstandingly the recognized authority in the prevention and cure of disease. Like the great religions of the world, it recognizes no geographical bounds, but unlike the great religions, it has no division of authority.

A recital of the long chain of distinguished men of medicine, with many links centuries long, reveals an unmistakable continuity. To mention them individually, is to count the beads of a great rosary, one by one, each bead a jewel of rare worth and beauty. It is a record of singular interest.

[1]Presented before American College of Surgeons, Boston, October 8, 1928

Every physician is assumed to have a knowledge of this history, but he should know it accurately; and for protective information, the cultural education of each person—man, woman, and child—should include facts of medical history.

V. We Should Be Definite

For centuries the ART of medicine was paramount. This art was based on records which represented careful study of diseases, the effect of drugs, and the performance of operations in dire emergencies only. Familiarity with the action of drugs was discovered and developed to an astonishing degree of exactness; and the proficiency with which the experienced practitioner influenced the different shades of diseases would excite the admiration of the skilled practitioner of our present ultra-scientific age. Like a master musician, the physician of yesterday studied and knew his organ, and no note was too subtle for him to reproduce.

VI. Scientific Medicine

The nineteenth century saw the development of the pure sciences. Rapidly these were absorbed by the medical profession, and now more than ever we may say that we practice the SCIENCE as well as the ART of medicine. Long experience in recorded observation is not the only basis of our accomplishments; but as well the mathematical certainties of pure science and its instruments of precision.

During twenty-five years I have had an unusual opportunity to observe the rapid changes in the development and practice of clinical medicine and surgery. Besides the practice of surgery, this experience was gained in five activities: organizing and administering SURGERY, GYNECOLOGY AND OBSTETRICS; developing the Clinical Congress of Surgeons; founding and conducting the American College of Surgeons; responsibility of organizing the lay medical corps for service in the Great War; and reorganizing the Gorgas Institute of Tropical and Preventive Medicine. In the development of these five important activities, I have been intimately in touch with the profession; and as an innocent bystander, I have accumulated knowledge and not a few notions about the present evolution.

It is my purpose this evening to review some notable events from a mass of material that has been systematically compiled and placed in manuscript form, whose reading would be interesting, but whose presentation in an address would be appalling.

First and foremost are the scientific accomplishments that have definitely modified and controlled specific diseases, and incontrovertibly conserved life and health in a revolutionary manner: The work of Pasteur, and its adoption by Lister in the development of antiseptic surgery; the outstanding pursuits of Koch in modifying tuberculosis; the epoch-making researches by Behring, Roux, and Klebs in controlling diphtheria; the indefatigable labors of Ehrlich in furnishing a remedy for the spirochætal diseases; the achievements of Roentgen; of Eberth in well-nigh exterminating typhoid fever; the painstaking accomplishments of Bruce in sleeping sickness; Ross and Laveran in malaria; our own Reed, Finlay, and Gorgas in yellow fever; Banting in diabetes; and the Dicks in scarlet fever. These specific accomplishments have resulted in saving more lives each year than were lost in the Great War.

VII. Degenerative Diseases of Middle Life and Old Age

There are certain other diseases that reap a large death harvest and a much greater disability. Though we have not a specific for each, we have definite proof that they may be modified or cured if discovered early. These include the degenerative diseases, insidiously begun in middle life and exaggerated in old age; notable among them: cancer, with a mortality of 115 in every 1,000 deaths, though if recognized early it may be cured; heart disease, that makes its deadly swath in individuals in the most productive period of life, 140 to every 1,000 deaths, may be modified if early recognized and appropriately treated; diseases of the kidneys and blood vessels, with their harvest in middle life of 110 in 1,000 deaths. Preventive medicine, or the early application of curative measures in these diseases, would save thousands of lives each year.

So to extend longevity to any material degree, we must first discover the cause of, and secure a remedy for, degenerative diseases. It is my prophecy that we are on the eve of solving the unknown problems which pertain to the diseases that cause unforeseen and unexpected tragedies in middle life, and that germinate and foster the dread of incapacity in old age.

The degenerative diseases cause one-third of our deaths. They are definitely influenced by concurrent incidents, as habits of living, strenuous mental activities, improper diet, excessive use of stimulants, particularly alcohol, lack of proper exercise and recreation, and infectious diseases that thrive on a weakened resistance. They are the result of age or its equivalent—excessive work.

Within a year, at the Third Race Betterment Conference, President C. C. Little, of the University of Michigan, stated:

> There seems to be little doubt that man's average duration of life is being increased. The majority of statistical and other observations point in that direction. . . . Making the average age of human life 68 or 70 or 72, as the case may be, is very different from increasing the upper age limit to 120 or 140. . . . To increase the upper age limit of life, that is, to make a new maximum age for human beings and to make it a fairly common thing to attain that age, would mean that we would have to extend or prolong a process known as senility. All of us know what it means to grow old. We should either have to prolong that process of growing old, making it more gradual, or we should have to extend it to a higher age, that is, postpone its start. Neither of those things is very easy to do. It is along that line, perhaps, that less progress has been made than the claims of many enthusiastic individuals would lead us to believe was the case. . . .

It is my belief that this statement was dangerous, as it was put forward by an influential teacher of men and women. It is an opinion of a pure scientist who bases his statements on accepted and established scientific facts; but we are reminded every day by the world's progress that so-called scientific facts are not necessarily permanent facts. Frequently they have been, are being, and will have to be revised as knowledge is augmented and experience advanced.

Diabetes is the result of degeneration of gland tissue in which is secreted a substance that aids in regulating the absorption of sugar in the circulation. Dr. Moses Barron, of Minneapolis, in an article in SURGERY, GYNECOLOGY AND OBSTETRICS revealed a method of isolating that secreting tissue. Barron's article was read by another (then obscure) student, whose mind was not cluttered with scientific facts that dimmed his vision; he rushed across the Atlantic, placed his conclusions before his laboratory teachers in his Alma Mater in Toronto, and gave to medicine Insulin, a remedy for diabetes, one of the great discoveries of the age.

Would Edison, if he were told that the degenerative diseases were said by scientists to be unmodifiable, say: "Well, then we must give it up?" Wouldn't he say that many things are being wrought every day that seemed impossible of accomplishment in the light of science and tradition?

The science of chemistry, endocrinology, biology, physiology, clinical pathology, and basal metabolism, is tackling and solving new problems every day. Adrenalin, thyroxin, insulin, and pituitrin are examples of exact and progressive accomplishments. Undoubtedly the substances that will control the degenerative diseases are now in the making.

Scientists today are mining the materials; men of vision are fitting these materials into practicable theories; and practical men are straining at their leashes ready to utilize these materials and make great visions come true.

VIII. Public Health

We know to a mathematical certainty the contributions of scientific medicine toward public health (in contradistinction to personal health) in comprehensive hygienic regulations and general sanitation. The findings of scientific medicine, through civic and other governmental authority, are applied to purify the water supply, to dispose of sewage, to protect and conserve the purity of food, to ventilate public buildings and places of amusement—gifts which the lay public has accepted almost unanimously; and all civilized countries realize the extent to which life is protected and wholesome living insured through the provisions of scientific medicine.

IX. Summarized Statement

Thus, briefly, the ever-lengthening list of impressive accomplishments reads like a romance. To physicians it is an old story with many sidelights, endless in their ramifications. To the layman and woman its history, written in popular style, would be not only intensely interesting reading, but it would be more valuable in stimulating race betterment and human happiness than any biography ever written.

X. The Heritage Emphasizes Our Sins of Omission

Ours is an unique heritage from a most ancient and accomplished profession. Are we, as trustees, doing our utmost to perpetuate and extend these doctrines? Is the public unmindful of its legacy through ignorance, indifference, or false teaching? Whose is the paramount responsibility to supplant ignorance with knowledge, indifference with interest, and false teaching with truth? The practitioners of medicine themselves!!!

XI. Scientific Medicine and Personal Health

In my review I have endeavored to ascertain what would be the result if the doctrines of scientific medicine were applied in a maximum degree toward the conservation and preservation of personal health, and toward the alleviation and cure of existing disease. It must be obvious that the effect in prolonging life would be phenomenal; and in extending wholesomeness of living, and happiness in pursuit of life, inestimable. Our past and present methods have confined our activities to curative medicine, almost to the exclusion of preventive medicine.

XII. Who Resists the Benefits of Scientific Medicine?

Though it be impossible to speak with exactness, it is a safe assumption that of the 130,000,000 people in the United States and Canada, one-half of those of reasoning age have no familiarity with the simplest fundamentals of the laws of health. While this proportion of our population is ignorant of the importance of health laws, it is again a safe assumption that false teachings by propagandists, and one or another reasons have led at least another one-fourth of our reasoning population to develop a positive antagonism to scientific medicine, and definite resistance to its services. Those who oppose scientific medicine thrive more or less successfully according to the advertising zeal of their leaders; they represent the various sects, cults, and organizations of proprietary and patent medicines.

XIII. Results of This Resistance

If it is true that one-fourth of our population of reasoning age represents active opposition to curative medicine, and succeeds in avoiding its ministrations, here is a sound basis on which to estimate the effect of this on the health and mortality of the whole population.

Thus our favorable showing is possible with non-resistance or indifference of one-half of the population of thinking age. Estimating that one of every four resisted the services of scientific medicine—refused vaccination for smallpox, antitoxin for diphtheria, and appropriate prophylaxis in the other preventable diseases—a large proportion of the present death rate in these diseases is avoidable and may be attributed to this resistance. An ultra-conservative estimate (under accepted methods of statistical study and mathematical calculations) will attribute to this one sin of omission 8,790.6 avoidable deaths in 1925, and 87,906 avoidable deaths in the ten years, 1915 to 1925.

With one-fifth of our population yielding to and accepting an annual health audit (as our figures indicate), with two-thirds of them sympathetic to curative medicine, and with two-thirds spiritually and morally in favor of the enforcement of the 18th Amendment, we need not wait until the next decade or the next century to reap the benefit in life extension.

XIV. Education Is Necessary

The remedy is but too obvious. There must be continuous education. The fundamentals of scientific medicine, its practicability and acceptability, should be taught in the primary classes of our public and private schools, as early as the seventh or eighth grades. The fundamental principles of scientific medicine should occupy the same relative position of importance in the grade schools as grammar, general and physical geography, lower mathematics and English literature. The influence of these principles on personal and public health should be emphasized and reiterated, and knowledge imparted of the laws of general hygiene and sanitation.

A number of experiences in addressing school children convince me that education in the basic principles of scientific medicine would be accepted by them with great enthusiasm; and the leaven there sown would be of incalculable aid in lessening the existing ignorance and indifference toward the maintenance and promotion of better health. Moreover, in a dignified and proper manner it would be a potent factor in combating misinformation, which, uncurbed, develops into opposition to the truths of scientific medicine.

The five million men who served in our armies in the Great War were quick to appreciate the importance of the policy of our medical department to KEEP THEM WELL. The demonstration in the armies of our allies and enemies was even more impressive, as their men were under scientific medical surveillance for longer periods. So astounding were these demonstrations that practically every country engaged in the Great War (excepting of course the United States) was forced by public opinion of their soldiers to add to their respective cabinets a portfolio on medicine, under whose supervision curative medicine was made accessible to all people.

XV. Periodic Health Examinations

Preventive medicine and its counterpart, periodic health examinations, have been discussed since the earliest days of medical science. If scientific medicine has established its right to assume the responsibility of supervising and maintaining the health of the people, it is a foregone conclusion that it should examine each and every individual at definite intervals, and give advice based on the findings.

Resistance to this obviously significant policy is a sin of omission, due, primarily, to the shortsightedness of the physician who is educated in and practicing scientific medicine, and, secondly, to indifference of the public which is the beneficiary of such a policy.

This subject has been much in evidence in the last ten or more years. No one group of physicians, no one organization alone, can successfully influence this change.

I am indebted to James A. Tobey, Administrative Secretary of the National Health Council, for the following brief history of the movement:

Periodic examinations for life insurance companies were suggested about 1870 by a Dr. Dobell in England; and a Dr. Bares, a French hygienist, urged them some twenty years ago, though there is no record of either of these recommendations having been adopted at the time. In the United States, Dr. George M. Gould, of Philadelphia, contributed a paper to the *Journal of the American Medical Association* as early as 1900 in which he advocated regular "personal biological examinations" of apparently well individuals.

A definite plan for life conservation, which included a recommendation by Dr. Burnside Foster for periodic physical examinations every five years, was submitted in April, 1909, to the Association of Life Insurance Presidents. The Provident Life Assurance Society, of which Dr. Eugene L. Fisk was then Medical Director and Mr. E. E. Rittenhouse, President, was the first to adopt this plan for its policy holders later in the same year. In 1911, Mr. H. J. Messenger, the actuary of the Travelers Insurance Company, urged life insurance companies to take up these measures. In 1914, Dr. S. S. Goldwater, Commissioner of Health of New York City, announced the establishment of the system among the employees of the City Health Department. The late Dr. H. M. Biggs, Commissioner of the New York State Health Department, was also an ardent advocate of such examination for a dozen years. In a masterful paper read before the National Conference of Social Work in Washington, D. C., on May 17, 1923, this distinguished sanitarian put the health examination first in a list of eleven objectives in public health for the next twenty years.

Health examinations in industry began about 1913, in which year Dr. W. Irving Clark published a paper on the subject in the *Journal of the American Medical Association*. The following year Drs. H. E. Mock and J. W. Scherescheswsky reported on results of examinations in industry. Physical examinations for the general public have actually been offered on a self-supporting business basis since 1914 by the Life Extension Institute.

Practical work along this line has been enthusiastically developed by the Metropolitan Life Insurance Company.

Special semi-public organizations, conspicuously the National Tuberculosis Association and the American Society for the Control of Cancer, the former twenty-four years ago, the latter sixteen years ago, began to urge periodic health examinations so that the signs of the respective disease in which they were interested might be discovered early; and later their example was followed by the American Child Health Association, the American Social Hygiene Association, the American Heart Association, et cetera. Naturally it soon became obvious that preventive medicine could be more systematically advanced if the public were educated to accept a comprehensive periodic examination that would reveal the early signs of any disease instead of some particular disease.

The Great War emphasized the wisdom of thorough physical examinations, as every country which entered the conflict arbitrarily exacted a medical examination of its soldiers. In some countries the examinations may have been too hastily and too superficially carried out, because of the rapid development of the conflict. But the United States, with its greater deliberation, included in its draft law a provision by which every soldier underwent a health examination conducted, not by one physician alone, but by a group of specialists.

This, no doubt, was the most impressive demonstration, and certainly the most extensive one, on the value of a comprehensive health audit of a large group of apparently healthy men.

The medical corps of the Army, under General Gorgas, alone accepted for service, medically, 4,500,000 of these fit men; and to secure this number it was necessary to examine approximately 7,000,000 young men. The difference in these figures represents those who were unfit.

These demonstrations, with examinations for special diseases, gave great impetus to the propaganda in favor of all-round periodic examinations. In 1919 and 1920 this organization, the American College of Surgeons, organized its sectional meetings, since which time we have held sessions in practically every state of the United States, and every province of Canada. The principal innovation is the carefully planned meeting for the laity at which, in simple language, the layman and woman are given information on the fundamentals of scientific medicine, and especially the advantage of periodic health examinations. The Gorgas Memorial Institute of Tropical and Preventive Medicine was organized in 1921. As the activities of the Memorial have developed, it has more and more urged upon the public the importance of seeking an annual health audit by the family physician.

In May, 1922, the Trustees of the American Medical Association urged the members of organized medicine, through the county medical societies, to encourage such examinations. Blanks were developed by the Association for that purpose in May, 1923, and in 1925 the Association also prepared for the use of physicians a comprehensive manual which contains very useful hints on the method of conducting these examinations. Dr. William D. Haggard, in his Presidential Address before the parent organization, very eloquently advocated the periodic health examination; and Dr. Wendell Phillips made the subject an important theme of his Presidential Address.

XVI. Educated Pilots

The public should know what we know—that in a large number of our states, individuals are licensed to practice the healing art who are utterly ignorant even of the barest fundamentals of scientific medicine; cultists, some of whom have not even a rudimentary knowledge of the basic sciences, of anatomy, physiology, chemistry, bacteriology, pathology, diagnosis, or the other primary essentials of a medical education; cultists, some of whom utterly ignore or denounce the necessity of possessing any knowledge whatsoever of these indispensable requirements. The various cults, under sundry names, have gained the sympathy of legislatures. By subtle sophistry, they have passed laws which require farcical examinations in one or another pathy or cult, authorized license to practice medicine or even surgery, and have caused them to be recognized as legal practitioners of the healing art, with all of the rights and privileges of the scientifically educated physician.

Of the forty-eight medical practice acts authorized by the individual states of the United States, only five require that an individual, to be licensed to practice the healing art, shall show by examination that he has a knowledge of the basic sciences upon which, obviously, the practice of the healing art should be grounded. This means that in the other forty-three states of the United States not requiring the basic science examination, only the graduates in scientific medicine meet these qualifications.

The new basic science law requires that every practitioner of the healing art shall pass successfully an examination in the basic sciences before he is eligible to present himself as a candidate to the state board of examiners for a license to practice medicine or the healing art in any form recognized in the medical practice act of the respective state. The law drawn up by Dr. William C. Woodward, Executive Secretary, Bureau of Legal Medicine and Legislation, American Medical Association, is, in my opinion, the simplest basic science law that has been suggested, and at the same time contains all essential protective requirements. The first section of the "Enacting Clause" reads:

> Basic Science Certificate Required. No person shall be eligible for examination or permitted to take an examination for a license to practice the healing art or any branch thereof, or granted any such license, unless he has presented to the licensing board or officer empowered to issue such a license, a certificate of ability in anatomy, physiology, chemistry, bacteriology, pathology, diagnosis and hygiene (hereinafter referred to as the basic sciences), issued by the state board of examiners in the basic sciences.

XVII. A Solution for the Promotion of Successful Health Examinations by the Personal Physician

In obtaining thorough health examinations, how can we insure the independence of the family doctor, the personal internist, and the favorite surgeon? How insist upon a thorough and complete health audit, save the public from the exploitation of unworthy groups, stock companies, or even the well organized clinics or well equipped dispensaries or hospitals, and yet not lose to the personal physician his control of his own legitimate clientele? On this point even the advocates of the health audit have been most apprehensive, and their consternation has led them almost to the point of abandoning the program, lest in spite of its advantages the independent practitioner be put out of business.

The American College of Surgeons is successfully working out a remedy, a supremely practical solution of the problem, that will be satisfactory equally to the laity, the independent practitioner, public health officials, and the hospitals. Obviously, the difficulty lies in the fact that no one practitioner, regardless of ability and eminence, can individually overcome the prohibitive difficulties and make a complete health audit, unless he has at his command competent aids, and intricate scientific apparatus and laboratories.

Where is the environment that will remedy this difficulty? Where do Barker, Charles Mayo, Christian, or Cushing find satisfactory surroundings? The answer: In well organized groups; organized clinics; *the standardized hospitals*. Which of these could, without prohibitive confusion, furnish to the independent physician a place where he could personally make a comprehensive scientific examination of his patient, retain his independence, and not lose control of his own business? A little consideration will answer this query in favor of *the standardized hospital*.

XVIII. The Health Inventorium

The "Health Inventorium" is planned by the College to meet this exigency. The suggested plan was submitted to one-tenth of the 1,805 hospitals in the United States and Canada on the approved list of the College in 1927. Almost without exception the plan was accepted. Thereupon, the plan was submitted to all hospitals on our approved list in 1927, and finally there is a thorough discussion of the subject at our hospital conference during this session of the Clinical Congress. The fundamentals of the plan have met with almost unanimous approval.

The plan briefly summarized is as follows:

1. Every standardized hospital shall furnish an examining room or rooms, to which any legalized practitioner, who is a member in good standing of his respective county medical society and the American Medical Association, may bring a patient for examination. There shall be no charge for the examining room.

2. The hospital shall furnish to the practitioner every facility in the way of aids, consultants when necessary, laboratory tests, etc., as will insure a comprehensive audit of his patient's condition.

3. The charge for the required laboratory tests shall be nominal, and a maximum of actual cost.

4. The physician shall render to the patient a bill covering his fee for the examination, and where there is a charge for laboratory services, he shall be responsible to the hospital for its payment.

5. No hospital shall accord these facilities to any individual who is not accompanied by his or her doctor, or who does not carry a letter from his or her doctor in which certain services are requested.

6. An individual who applies for an examination and who has no physician should be referred to a duly appointed, disinterested committee consisting of a representative or representatives of the county medical society and the standardized hospitals of the community, and this committee shall advise the patient in the selection of a physician.

7. Except in dire emergency, no hospital shall treat a patient who was examined in the Health Inventorium, except by request or consultation with the referring physician.

XIX. The Demand for Health Examination and Its Acceptance

It is not surprising that life insurance companies should advocate and be ready to lend financial support toward popularizing periodic health examinations. This commendation only emphasizes their importance. They recognize the movement as a substantial business asset, as it will extend the life of their policy holders, reduce the cost of insurance, and incidentally substantially increase profits. Are not these facts, substantiated by business sagacity, evidence that you and I, as policy holders, too, will profit in longer life and better health?

Dr. Augustus S. Knight, of the Metropolitan Life Insurance Company, recently at my request gave me figures to indicate the increase of demand and acceptance by the policy holders of yearly examinations advocated and provided by several of the larger insurance companies.

The Prudential Insurance Company of America reports 1,500 examined in 1920, and 58,000 in 1927, or an increase of 3,867% in eight years.

The John Hancock Mutual Life Insurance Company, 146 in 1925, 1,487 in 1926, and 2,617 in 1927, or an increase of 1,792.5% in three years.

The Penn Mutual Life Insurance Company reports 568 in 1923, 1,651 in 1927, or an increase of 290.5% in five years.

The New England Mutual Life Insurance Company did not offer examination until 1925. In

TABLE I.—SUMMARY

	1920	1922	1923	1924	1925	1927	Percentage of increase
Prudential Insurance Company of America	1,500					58,000	3,867 (in 8 yrs.)
The John Hancock Mutual Life Insurance Company					146	2,617	1,792.5 (in 3 yrs.)
Penn Mutual Life Insurance Company			568			1,651	290.5 (in 5 yrs.)
New England Mutual Life Insurance Company					Began	4,600	—
Equitable Life Assurance Society	4,554					25,030	549.5 (in 8 yrs.)
Metropolitan Life Insurance Company	10,904					92,361	847.04 (in 8 yrs.)
Life Extension Institute	13,233					105,366	796.2 (in 8 yrs.)
Cornell Clinic		147				645	438.7 (in 6 yrs.)

1927, approximately 4,600 examinations were given.

The Equitable Life Assurance Society reports: 4,554 in 1920, and 25,030 in 1927, or an increase of 549.5% in eight years.

The Metropolitan Life Insurance Company reports: 10,904 health examinations in 1920, and 92,361 in 1927, or an increase of 847.04% in eight years.

Life Extension Institute—13,233 examinations in 1920; 105,366 in 1927; 796.2% increase in examinations in 8 years.

Cornell Clinic—147 examinations in 1922; 645 in 1927; 438.7% increase in 6 years.

The approximate increase in demand for periodic health examinations with companies which give figures for 1920 and 1927, ranges from the encouraging figures of 549.5% to 3,867% (Table I).

Considering the short time occupied in the experiment, this is a showing that demonstrates a substantial interest by the people. Notwithstanding a reluctance on the part of not a few policy holders to accept the service on the ground that it is not an entirely disinterested activity, it is a movement that will develop incalculable health conservation.

XX. Indemnity Companies

Our College has been asked by a number of the important indemnity companies and industries who must provide protection to their employes to make a survey that will assist them to give the highest degree of protection to the employed in industry. As a result, through our Board on Traumatic Surgery, we made careful inquiry into the protective measures and health care that are provided to the great number of employes in large corporations. Our close contact with the hospitals of the United States and Canada makes this new survey dovetail very fittingly and economically with our yearly survey of the hospital field.

XXI. Industries

While indemnity companies and state laws furnish protection to men who labor in the industries, in the last analysis, such indemnity protection is financed by the industries themselves. Wisdom and efficiency have led a considerable number of the larger corporations who employ labor to adopt methods of self-protection by furnishing to their men every facility that scientific medicine offers in the way of preventive and curative health measures; and similar facilities are provided also to their entire administrative force. The beneficent effect of this system in preserving health and furnishing the best surgical and medical aid in case of injury or illness is not of less importance because it results in a financial saving to the industries which furnish the aid; but it is the most substantial and effective commendation of scientific medicine and its relation to personal health.

Our survey indicates that this form of humanitarian service has increased enormously since 1920.

Questionnaires sent: 172

Replies received: 61 (which represent approximately 844,053 employes)

1. Medical service and periodic supervision:
   - 27 report complete and compulsory service
   - 5 report partial service
   - 15 report service on employment only
   - 1 reports service after 45
   - 1 reports service for factory employes only
   - 1 reports service for office employes only
   - 6 report no medical service
   - 3 report medical service optional
   - 2 did not answer question
2. Attitude toward the service:
   - 31 report employes welcome it
   - 6 report employes tolerate it
   - 4 report prefer own physician
   - 20 did not answer question
3. Medical service extended to families of employes:
   - 5 report yes
   - 19 report occasionally
   - 22 report no
   - 15 did not answer question
4. Increase, 1920 to 1928, in number of periodic health examinations:
   - 1 reports 700%
   - 1 reports 300%
   - 1 reports 100%
   - 4 report 75 to 80%
   - 2 report 50%
   - 4 report great increase
   - 7 report 10 to 40%
   - 2 report no increase
   - 39 did not answer question
5. Estimated percentage unsuspectingly harboring some disease or physical defect:
   - 5 report 90%
   - 1 reports 75%
   - 4 report 50%
   - 5 report 35 to 45%
   - 4 report 15 to 25%
   - 6 report 10%
   - 4 report 4 to 8%
   - 1 reports many
   - 31 did not answer question

6. Age when degenerative diseases manifest themselves:
8 report ages 30–40
18 report ages 45–50
6 report ages 50–60
1 reports all ages
1 reports depends on individual
27 did not answer question

7. Probable result in preventing, modifying, postponing or curing degenerative diseases:
26 report much benefit
10 report some benefit
1 reports one-half ignore advice
3 question the value
21 did not answer question

8. Probable effect in increasing longevity:
28 report great benefit
6 report increase life from 4 to 10 years
2 report increase life from 10 to 20 years
4 report some help
21 did not answer question

The above summary represents 61 replies from industries which employ 844,053 individuals.

XXII. Labor

Labor has not been slow to recognize the importance of this movement. Samuel Gompers, outstanding statesman of labor, during his lifetime earnestly and continuously urged his great army of followers to ally themselves with scientific medicine. His worthy successor, William Green, the present President of the American Federation of Labor, is backing the program of our College to improve the status of industrial surgery and medicine. There is no power greater than organized labor to influence the advancement and extension of scientific medicine. Following the demonstration of the care of men in industry, especially in the production of munitions and other materials for warfare, the average increase in yearly health audits among labor men, based on our survey, is approximately 95% since 1920. This favorable showing is possible because most of the industries surveyed had similar service in 1920.

XXIII. Army and Navy

As early as 1905, Theodore Roosevelt, with his alert mind, looked with appreciative vision upon this problem of keeping physically fit; and, characteristically, he acted. Why have weak links in the United States Army, Navy, Marine Corps, and Public Health Service when by proper medical supervision the unfit units could be weeded out? From that time to the present the United States soldiers, sailors and marines have been submitted to regular physical examinations. The benefits of that program are now extended to the members of their families. By this regulation alone, over one million citizens are examined yearly and receive the benefits of preventive medicine.

XXIV. United States Army, Navy, and Governmental Departments

Questionnaires sent: 10. Replies received: 9

1. Are medical service and supervision provided:
2 report compulsory service
6 report service (entrance only)
1 reports no service

2. Total number represented:
5 replies represent 609,786 individuals
4 did not answer question

3. Attitude toward the service and supervision:
3 report welcome it
6 did not answer question

4. Is service extended to families:
1 reports occasionally
8 did not answer question

5. Increase, 1920 to 1928, in number of periodic health examinations:
2 report compulsory prior to 1920 and since
7 did not answer question

6. Estimated percentage unsuspectingly harboring some disease or physical defect:
1 reports 6%
8 report no data

7. At what age do degenerative diseases manifest themselves:
1 reports ages 38 to 40
2 report age 45
6 did not answer question

8. Probable result in preventing, modifying, postponing, or curing degenerative diseases:
2 report prolong life
1 reports reduce morbidity and mortality
6 did not answer question

9. Probable effect of periodic health examinations in increasing longevity:
1 reports 10% increase
1 reports 25% increase
3 report increase
4 did not answer question

XXV. Elementary and Secondary Schools

In the last ten years, in my travels, and talks at sectional meetings of the American College of Surgeons, I have found well organized educational departments in practically every state of the United States and every Province of Canada. With few exceptions primary schools, and authorities in higher education, are careful to note the physical well-being of pupils. It is an exception

if the authorities do not insist upon vaccination against smallpox, examination of the throat, tonsils, hearing, and eyesight. As an authoritative statement on this subject I herewith submit an analysis of our survey which summarizes the activities of the health authorities of eight cities of the United States with a population of not less than 250,000 each.

Questionnaires sent: 13
Replies received: 8

1. Are medical service and supervision provided to students:
   - 5 report compulsory with all students
   - 1 reports optional with all students
   - 1 reports compulsory (entrance only) with all students
   - 1 reports optional (entrance only) with all students
2. Total number of students: 2,308,349
3. Attitude toward medical service and supervision:
   - 7 report welcome it
   - 1 ⅔ report welcome (⅓ refuse, mainly Christian Scientists, chiropractors, etc.)
4. Increase, 1920 to 1928, in number of periodic health examinations:
   - 41% average increase
   - 3 did not answer question
5. Estimated percentage unsuspectingly harboring some disease or physical defect:
   - 50% average
   - 1 did not answer question

XXVI. Institutions of Higher Learning

Questionnaires sent: 13
Replies received: 4

1. Are medical service and supervision provided to students:
   - 4 report yes
2. Total number of students: 51,370
3. Attitude toward medical service and supervision:
   - 4 report welcome it
4. Increase, 1920 to 1928, in number of periodic health examinations:
   - 225% average increase
   - 2 did not answer question
5. Estimated percentage unsuspectingly harboring some disease or physical defect:
   - 1 reports 50%
   - 1 reports many
   - 2 did not answer question
6. Probable effect in increasing longevity:
   - 1 reports increase life 10 years
   - 2 report great benefit
   - 1 reports increase life 10 to 15 years

XXVII. Employes of City and State Health Departments

Questionnaires sent: 26
Replies received: 16

1. Are medical service and supervision provided to employes?
   - 9 report no medical service
   - 7 report yes
2. Total number of employes: approximately 5,000
3. Attitude toward the service and supervision:
   - 6 report employes welcome it
   - 2 report employes tolerate it
   - 1 reports employes prefer own physician
   - 7 did not answer question
4. Is service extended to families:
   - 9 report never
   - 3 report only when requested
   - 4 did not answer question
5. Increase, 1920 to 1928, in number of periodic health examinations:
   - 1 reports 37%
   - 2 report 100%
   - 1 reports 500%
   - 12 did not answer question
6. Estimated percentage unsuspectingly harboring some disease or physical defect:
   - 1 reports 3%
   - 1 reports 10%
   - 1 reports almost all
   - 13 did not answer question
7. At what age do degenerative diseases manifest themselves:
   - 1 reports ages 35 40
   - 4 report ages 40 45
   - 1 reports age 50
   - 1 reports ages 40–60
   - 1 reports ages 55–60
   - 8 did not answer question
8. Probable result in preventing, modifying, postponing, or curing degenerative diseases:
   - 1 reports questioned the value
   - 8 report beneficial
   - 2 report postpone
   - 1 reports 60% improvement
   - 4 did not answer question
9. Probable effect of periodic health examinations in increasing longevity:
   - 12 report great benefit
   - 4 did not answer question

XXVIII. Estimated Increase of Demand for Examination

A questionnaire was sent to several groups of leaders in the profession, and the replies were most impressive.

371 questionnaires to Fellows of the American College of Physicians (born 1881–1890);
276 questionnaires to Fellows of the American College of Physicians (born 1875–1880);
189 questionnaires to Active Members of the Association of American Physicians;
52 questionnaires to Emeritus Members of the Association of American Physicians;
25 questionnaires to Associate Members of the Association of American Physicians;
80 questionnaires to General Practitioners (selected at random) in towns of 10,000 or less.

Question No. 1: "In your own practice, what is the percentage of increase (between years 1920–1928) in the number of periodic health examinations of apparently healthy individuals?" There were 254 replies, the largest proportion from the younger group of physicians. A definite percentage of increase in number of examinations was reported by 189.

54 report from a slight to 15% increase
43 report from 15% to 40% increase
28 report from 50% to 90% increase
18 report 100% increase
25 report from 200% to 500% increase
5 report from 800% to 1000% increase
1 reports 2875% increase
15 report very much greater percentage
38 did not reply specifically
8 report not in practice. 19 report no increase

Question No. 2: "Among apparently healthy individuals thus examined, what percentage were unsuspectingly harboring some form of disease or physical defect?"

61 did not answer question
1 reports questionable
9 report none
10 report few
88 report from 1% to 20%
28 report from 21% to 45%
25 report from 50% to 70%
24 report from 75% to 95%
7 report 100%. 1 reports large number

Thus, to summarize these two tables, we discover that there is a growing interest in periodic health audits on the part of apparently healthy laymen, women, and children.

The questionnaire also exhibits our profession's wholesome interest in this subject. With better facilities furnished to the general practitioner, through our Health Inventorium, and the increased demand for periodic health examinations on the part of the public, this preventive measure for conserving health and life will make notable progress in the next few years.

Briefly, we note by the questionnaire: Question 1, that there has been an increase, between the years 1920 to 1928, on a conservative estimate of reports, of approximately 1% to 1,000% in examinations of apparently healthy individuals. By Question 2, that of the individuals examined, who were apparently well, from 1% to 100% were harboring unsuspected disease.

XXIX. Curability of the Degenerative Diseases

The diseases of middle life and advancing age, already referred to, are now attracting the attention of scientific medicine. What are they? At what age do they manifest themselves? Can they be postponed by thorough periodic audits? If they exist, can they be influenced by curative measures? And can the average limit of old age be advanced by careful surveillance, and scientific management?

These questions are important, not only to the scientific practitioner of preventive and curative medicine, but to every person, whether of early, middle, or advancing life, 33% of whom, at the present time, succumb unnecessarily early, and in the interval between birth and death suffer needless ills that destroy the pleasure of wholesome and healthful existence. In the second part of our questionnaire to this same group of practitioners, this subject was dealt with most interestingly by 228 doctors who honored us with replies.

Question No. 1: "In your experience, at what age do the degenerative diseases of old age manifest themselves?"

230 replies were recorded.
1 reports late teens
1 reports ages 15 to 45
2 report 30+
93 report 35 to 45
84 report 45 to 50
34 report 50 to 60
8 report 60 to 65
1 reports 75
1 reports questionable
3 report not matter of years
1 reports distinction between male and female, ages 40 and 50 respectively
1 reports distinction between whites and negroes, ages 46 and 40 respectively

The range of years for the development of degenerative diseases, from 15 to 75, with a large preponderance from 35 to 50 years.

Question No. 2: "What would be the probable result in preventing, modifying, postponing, or curing degenerative diseases of advancing age, if

each individual would have a yearly or more frequent examination and supervision?"

216 replies were recorded
73 report much good accomplished
66 report modify and postpone (of these 30 included "cure" and 40 "prevent")
35 report prolong life, increase efficiency
6 report no benefit
15 report fair
13 report very little good
8 report questionable

These 216 replies from the same group, most of them the leading, picked physicians of the United States, indicate a very great interest in degenerative diseases, and a belief that their course could be modified and postponed through these examinations.

Question No. 3: "Probable effect in increasing longevity."

232 replies were recorded
79 report increase life 10 to 20 years
4 report excellent
1 reports excellent after one generation
79 report marked increase
57 report some increase
9 report question the effect
1 reports no increase
2 report inheritance important factor

Question No. 4: "Do you advise your patients to submit themselves to periodic health examinations?"

241 replies were recorded
220 report yes
13 report occasionally
8 report no

SUMMARY OF REPLIES FROM TWELVE ORGANIZED CLINICS

Questionnaires sent: 23
Replies received: 12

1. Percentage of increase in periodic health examinations, 1920–1928:
   1 reports 500%
   1 reports material
   3 report 100%
   3 report 25%
   2 report 10%
   1 reports none
   1 did not answer question
2. Estimated percentage harboring some disease or physical defect:
   1 reports astonishingly high
   1 reports 100%
   1 reports 85%
   3 report 50%
   2 report 20%
   1 reports 10%
   2 report 5%
   1 did not answer question
3. Approximate age when degenerative diseases manifest themselves:
   From 35–60; mostly 45
4. Probable result in preventing, modifying, postponing or curing degenerative diseases:
   5 report prolong life
   3 report prevent, modify, postpone
   2 report fair
   2 did not answer question
5. Probable effect in increasing life:
   10 report prolong life from 4 to 10 years
   1 reports prolong life many years
   1 did not answer question
6. Does your clinic advise periodic health examinations:
   9 report yes
   1 reports occasionally
   1 reports no
   1 did not answer question

FINAL SUMMARY OF OUR INTERPRETATION OF THE FIGURES OF THIS INCONCLUSIVE SURVEY AND RESEARCH

(a) Estimated number of periodic health examinations of apparently healthy individuals—in 1920, 5,000,000; in 1927, 25,000,000; (b) One-third of the deaths in 1925 (or 502,083 deaths) are attributable to degenerative diseases of middle life and old age; (c) Degenerative diseases manifest themselves at average age of 45 years; (d) 236 replies from eminent internists, and 18 replies from general practitioners, indicate yearly examinations would modify and postpone the degenerative diseases, and increase longevity and the maximum old age limit; (e) 35% of apparently well individuals receiving periodic health examinations are found to harbor some form of unsuspected disease or physical defect; (f) 90% of our replies from internists and outstanding clinics reveal that patients are advised to submit to periodic health examinations; (g) Labor in industry, employes in governmental and civic organizations, pupils in elementary and secondary schools, colleges, and universities, practically all receive and welcome some form of personal periodic supervision, advice and service, and at least 17,500,000 receive complete periodic examination service; and an estimated additional 3,000,000 men and women, not included in the above, brings the grand total to 20,500,000.

The above figures, while not conclusive, indicate the enormous interest that is developing

in the subject of periodic health examinations. However, this is not a guarantee that all of these examinations now are to the highest degree comprehensive and efficient. The figures do indicate the lay public's receptivity to this important innovation. And their acceptance of the ministrations of scientific medicine places upon the profession a responsibility that should induce us to give a one hundred per cent service.

XXX. Curative Medicine and Surgery

Each day elective surgery alone—with early operations for cancer; goiter; prostatic degeneration; appendicitis; spinal, cerebral, biliary, gastric and infectious diseases—is extending the lower limit of longevity and restoring invalids to healthful living.

Given opportunity to examine individuals before disease is suspected, curative medicine, with its aids in diagnostic precision and its therapeutic accuracy, is keeping people well, curing the sick, and daily adding to the wholesomeness of living and the span of life.

XXXI. The Influence of the Physician in Gaining Co-Operation of the Public

A mistaken policy of silence, and a tradition of non-communicability in discussing the health problems of our patients, has militated against our full influence with the public. No profession, not even the ministry, can more effectually guide a large proportion of the community on a private or public policy. When we fail to exert this prestige, it is the fault of our profession and not of the public.

We have had three outstanding illustrations of this statement:

1. In 1920 the irregular practitioners of the healing art, the patent medicine venders in California, backed by subsidized newspapers, attempted to prevent animal experimentation in the teaching of medicine within the state. The scientific medical profession was aroused, the educated and sane people of that great state rallied to their support, and the antagonists of scientific progress were completely routed.

2. In 1922, a similar belligerent campaign against scientific medicine occurred in Colorado. For a time it appeared that the qualified doctors would have to forfeit those requisites which are indispensable to the teaching of their profession, and that the legislators of an important state were to turn thumbs down on the progress of civilization. Again, the scientific medical profession was aroused, exerted its influence, took the public into its confidence, told them the facts, obtained their co-operation, changed the tide toward sanity and common sense, and completely routed the opposition.

3. In 1921, Massachusetts, indifferent to the growth in its midst of the most subtle forms of irregular practices, found these same cults, who repudiated the conventions of civilization and considered themselves strong enough to terminate the teaching of scientific medicine, were organized to stop animal experimentation in the teaching of medicine. Slowly, but eventually, the profession of scientific medicine was aroused—they gained the co-operation of their patients, and together they routed the Knights of Unrighteousness beyond redemption.

The profession of medicine exerts a powerful influence, and can, if it will, convince at least 75% of our people that it is their inalienable right to be kept well, and that the scientific medical profession is the one authentic, accredited, and competent agency equipped to keep them well so far as is humanly possible.

Lay people, in the majority, are waiting for us to take the lead in the practice of the healing art; to halt our mysterious methods, and give them face to face facts and guidance so that they may be maintained in good health.

XXXII. General Summary

1. The profession of scientific medicine, organized before the advent of Christianity, is the eldest of learned professions. Spiritually, morally, and scientifically, in all civilized countries, it is outstandingly the recognized authority in the prevention and cure of disease. Like the great religions of the world, it recognizes no geographical or political bounds, but unlike the great religions, scientific medicine has no competitors. It is the one authority recognized by all civilizations.

2. For centuries scientific medicine was practiced as an art and every scientific truth employed to make its authority more worthy and reliable. With the development of the exact sciences, it has strengthened its art and made more definite its authority and accomplishment by appropriating the proved truths of modern science, until it is now known, and properly so, as the science of medicine.

3. As we have shown, problems of disease, one after another, have been and are being conquered, and not only the trained physician has this knowledge, but the educated layman, too, is prepared to accept preventive and curative scientific medicine as the recognized authority; and rapidly the public is improving the opportunity

to keep fit and submit to periodic surveillance by the practitioner of scientific medicine.

4. The thorough physical examination of millions of soldiers in the Great War, proved the value of scientific medicine, and convinced millions of men of the wisdom of a periodic physical audit, under the supervision of scientific medicine, to keep themselves well. Through systematic propaganda advocating preventive medicine to conserve personal health, the general public has become aware of the value of periodic health examinations; labor has been convinced of the value of keeping well; and the industries, as an economic asset, have been induced to establish scientific facilities to keep their employes to the highest degree in good health.

5. Change of opinion has been wrought in the minds of the laity, in their attitude toward the relative wisdom of periodic audits to preserve health, rather than to wait for illness to make evident a possibly incurable condition. A wholesome evolution in the practice of medicine is resulting, and it promises to become a boon that will preserve personal health to the maximum, and afford satisfaction to the scientific practitioner of medicine because of ability to practice his profession with greater precision and success.

6. The American College of Surgeons has occupied an important position in this movement, which must command the support of the teachers of medicine, the practitioners of medicine, the authoritative societies of medicine, the journals of medicine, and through all dignified means of publicity, it must educate the public to the necessity of co-operation with scientific medicine if they are to be protected from illness, and if the happiness of their lives is to be enhanced.

7. Statistics show that 25,112,309 individuals in the United States are employed in industrial occupations. According to our limited survey, one-half of these individuals receive medical service and periodic supervision; conservatively we estimate that of the total employed only one-fourth receive this service, or 6,278,077.

In the U. S. Army, Navy, and Marine Corps 250,188 of their personnel receive this thorough service, which is extended also to the members of their families. On the basis of four members in each family, this brings the estimate to 1,000,752.

There are in the elementary and secondary schools, universities, colleges and professional schools (continental United States) 27,381,816 pupils and instructors. Our survey shows that three-fourths of these receive medical service and periodic supervision, but conservatively we estimate only three-eighths, or 10,268,181.

SUMMARY

Individuals in industrial occupations who receive complete medical service and periodic supervision (estimated).	6,278,077
U. S. Army, Navy, and Marine Corps, and members of their families (estimated)	1,000,752
Pupils and instructors in elementary and secondary schools, universities, colleges, and professional schools of continental United States (estimated)	10,268,181
Further, it is estimated that an additional 3,000,000 men and women, not included in the above, receive complete and thorough periodic health examinations	3,000,000
Total in these four classifications who receive medical service and periodic supervision (estimated)	20,547,010

8. Through our recent research and study with the industries, labor, insurance, indemnity companies, governmental, state, county, and civic authorities, our universities, colleges, high schools, and primary schools, and others in their preventive health activities, from our direct questionnaire to our most influential practitioners of medicine, there is convincing evidence that the public is rapidly accepting the policy of co-operation with scientific medicine, and the practitioner of medicine is more and more willing to do his part, all of which offers conclusive proof that within the next ten years, the momentum of this evolution will find 30,000,000 of our people accepting the program of yearly health audits to conserve personal health, as readily as they now accept the protection provided to the masses by public health activities.

9. The health inventorium—which brings into the strong trinity of co-operation the scientific medical practitioner, the standardized hospitals, and the laity—when thoroughly understood and accepted, will insure to every practitioner adequate facilities to make thorough examinations, and to the public a thoroughly reliable service.

10. The questionnaire to internists and general practitioners reveals a keen interest in observation and study of the insidious diseases of middle and advancing age—the degenerative diseases, and most of them have expressed the definite opinion that yearly or semi-yearly health examinations will reveal these diseases in their incipiency, afford opportunity to modify and postpone the progress of many of them, and definitely prevent the development of some of them. Inasmuch

as one-half of our yearly deaths are attributable to diseases which reap their harvest in man's years of greatest usefulness, the significance of this authoritative information is apparent.

11. This review of the evolution of the progress of clinical medicine and surgery emphasizes our responsibility as practitioners of medicine. We must give service to the utmost of our ability, and with the lay public must rest the responsibility of accepting it. Volunteer acceptance of this program will:

(a) Preserve rather than restore the health of 100% of the people, to the greatest degree possible through the sciences;
(b) Require that practitioners of medicine be educated in the basic sciences before they may be licensed to practice the healing art;
(c) Make readily available to medical schools all facilities necessary to teach scientific medicine, and to preserve modern research methods in the laboratories by animal experimentation;
(d) Employ all dignified publicity methods, guided by scientific medicine, to enable the public to recognize the reliability of scientific medicine and to distinguish it from the subtleties of uneducated pretenders and imposters.

12. Alas, this review estimates that approximately one-fourth of the laity are now indifferent to the benefits of scientific medicine, and that approximately another one-fourth are antagonistic to it, the victims of sophists, quacks, and other unscientific practitioners. While this affects detrimentally the individuals of adult life whose wisdom should guide them to choose judiciously, and with whom it is futile to protest, unfortunately it also affects their innocent children and dependents, and results in much unnecessary sickness and many premature deaths. The increased health rate, and the number of lives saved in 25 years of this century by the application of scientific medicine, proves that the refusal of this large proportion of our people to accept our aid without doubt accounts for much unnecessary illness and suffering, and at least 17,581.2 preventable deaths each year.

13. More than two-thirds of our people morally and spiritually favor the 18th Amendment to the Constitution of the United States. In spite of the injudicious administration of this 18th Amendment, which has resulted in an orgy of law-breaking, of self-indulgence, and ridicule on the part of the other one-third of our citizens, the foundation has been laid for a demonstration of race betterment and extension of life that will astonish the world.

14. It is my wish that this review may aid to convince the people that one-half day each year should be set aside for a comprehensive health audit of each member of every family. As physicians we know the essentials and the details of scientific medicine. We believe that the layman and woman from childhood should have a convincing knowledge of the essentials of preventive medicine. This knowledge must be imparted by dignified publicity methods; by teachers who are educated physicians.

15. Speculation, though not conclusive, is interesting. If this reasonable program is accepted and acted upon (and the present attitude of the people indicates that it is being accepted and adopted), based on our comprehensive survey, I venture to predict that accurate statistics will record an extension of longevity from an average of 58 years in 1920 to 65 years in 1930; extension of middle age (40 to 70 years in 1920), to from 45 to 80 years in 1930; and a postponement of senility, and extension of the average old age limit, from its present average of 90 years, to 100 years or more in 1940. And, what is of greatest importance, periodic health examinations, with the resulting decrease in preventable illness, will add immeasurably to the wholesomeness and happiness of more than 100 millions of people in the United States and Canada.

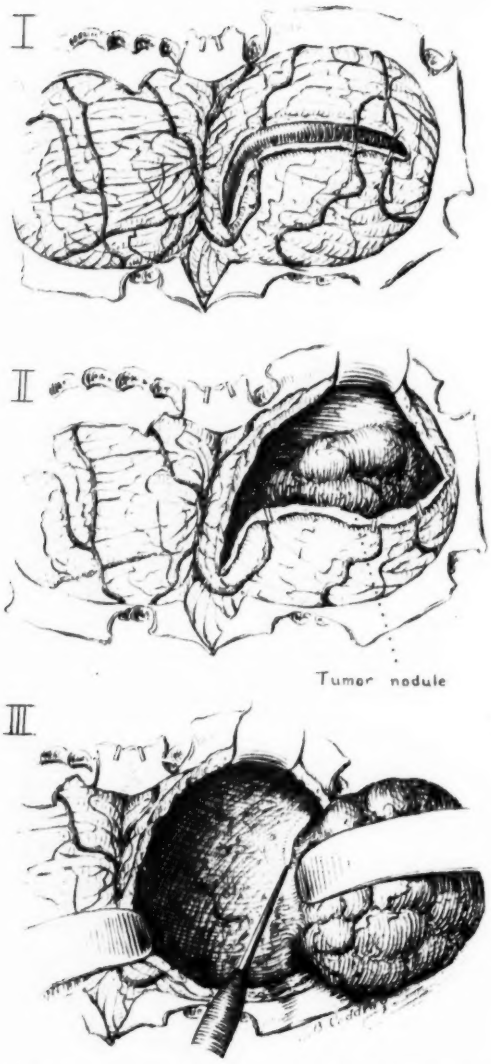


Fig. 36. Operative sketch (reduced ⅓) illustrating the steps of the electro-surgical removal of a large laterally placed mural astrocytoma (Surgical No. 31096).

Electro-Surgery as an aid to the removal of Intracranial Tumors.—Harvey Cushing